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War II
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Ended**

NOVEMBER 2008

Huge Ruby Found on Bali— Is It Yours?

Paradise is reflected in this magnificent 22½ carat ruby...but the price is the most heavenly.

On the tropical island of Bali, the air is filled with ancient mystery and perpetual festivity. Who would have thought that our deep sea diving trip to this romantic paradise would lead us to a treasure of giant deep red rubies. This beautiful isle is so vivid and untouched it has become the spiritual inspiration for many an artist. Bali has gardens tripping down hillsides like giant steps, volcanoes soaring up through the clouds, long white sandy beaches, and friendly artisans who have a long history of masterful jewelry designs.

We stumbled upon a cache of giant natural rubies at a local artisan's workshop. He brought these exotic Burmese Rubies to Bali and now we have brought them home to you. Our necklace showcases a genuine **22½ carat** facet cut ruby set in a frame of .925 sterling silver in the Balinese style. *That's right—22½ carats!*

The ruby, raised above the handcrafted Balinese silver detailing is surrounded by a bezel of sterling silver and then wrapped with a twisted rope. The Oval Ruby Pendant measures approximately 1¼" by 1½." This exotic pendant suspends from an 18" silver snake chain and secures with a spring ring clasp. Drape this pendant around your neck for a bold luxurious look. And, since rubies are rarer than diamonds, we hope your rings don't get jealous. Most likely, this will be the largest precious gemstone that you will ever own.



Compare the size of a 1 carat ruby to our 22½ carat Oval Ruby.

The real surprise is that you probably expect this stone to sell for 1,000.00s of dollars. But our Stauer adventurers will go to the ends of the earth to find smart luxuries for you at truly surprising prices. And of course, if you are not thrilled with this find, send it back for a full refund of the purchase price within 30 days. As you can understand, this is an extremely limited offer. With rare rubies of this outstanding size and shape, we only currently have less than 490 rubies and may not ever be able to replace them again.

JEWELRY SPECS:

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- 18" sterling silver snake chain
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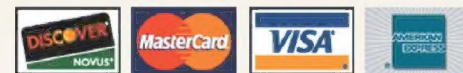
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ON THE COVER: By the end of the next decade, NASA plans to have U.S. astronauts back walking on the moon. On page 48, we take a guess at who they might be. From an Eric Long photograph of a shuttle spacesuit helmet (new moonsuits not yet available), designer Ted Lopez created our Mystery Astronaut illustration.



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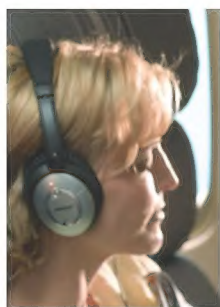


On the Web Site www.airspacemag.com

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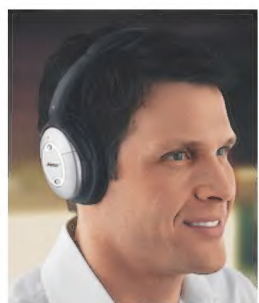
cabin, the bustle of the city or the distractions in the office, Bose QuietComfort 2 headphones help them fade softly into the background with the flick of a switch. You can savor delicate musical

nuances without disturbing others. And when you're not listening to music, you can slip into a tranquil haven – where you can relax and enjoy peace and solitude. Clearly, these are no ordinary headphones. It's no exaggeration to say they're one of those things you have to experience to believe.

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while faithfully preserving the music, movie dialogue or tranquility you desire. We designed these headphones primarily for airplane travelers. But owners soon started telling us how much they enjoy using them in other places to reduce distractions around them. They're excellent for listening to music whether you're on the go, at home or in the office.

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NASA's First 50

JUST WEEKS AFTER the National Aeronautics and Space Administration began work, 50 years ago this month, it launched its first spacecraft, Pioneer 1. The spacecraft went farther than any had gone before—more than 70,000 miles—but didn't achieve its goal of lunar orbit. A *New York Times* editorial called Pioneer a "glorious failure." Very quickly thereafter of course, the agency did reach the moon, and the glories of Apollo made the failures along the way seem like necessary steps to finally getting it right.

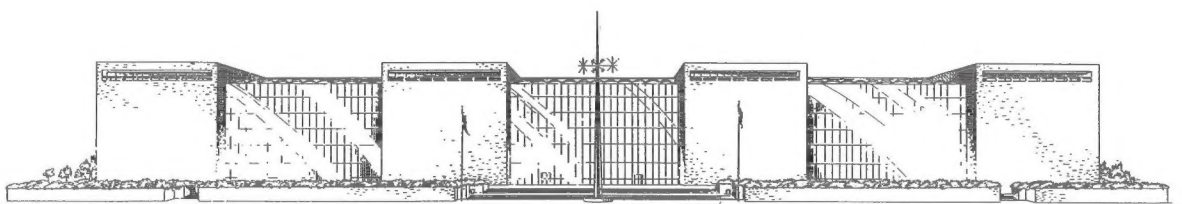
This issue of *Air & Space* celebrates NASA's 50th anniversary. The 50 photographs that curators in our space history division have chosen as NASA's most memorable (p. 30) remind us that NASA's first 50 years saw far more glories than failures. Looking at them, I'm struck by how many of NASA's greatest moments are reflected in the National Air and Space Museum's artifacts: the Mercury capsule *Friendship 7* in which John Glenn became the first American to orbit Earth; the Apollo 11 command module *Columbia*, which carried astronauts to lunar orbit and brought them home from the first moon landing; the Mariner, Pioneer, and Viking planetary explorers; a full-scale test model of the Hubble Space Telescope; and the space shuttle *Enterprise*. We also display the artifacts of NASA's aeronautical research, including the North American X-15, the fastest winged aircraft in history.

We've been proud to host the exhibition "Space: A Journey to Our

Future," which has been visited by thousands in the months it has occupied a first-floor gallery of the Museum on the Mall (see In the Museum, p. 14). It shows young people the marvels in store for anyone who plans to make space exploration a career. I'm especially pleased that it has been here in the National Air and Space Museum, where it ties the promise of NASA's next 50 years to the achievements of its first 50.

And that brings me back to the aptly named Pioneer. There were more than a dozen probes in the Pioneer series, and many of them performed brilliantly. When Pioneer 10 transmitted a last, faint signal to Earth in January 2003, it was more than 7.6 billion miles away—the second greatest distance that an object sent from Earth has ever traveled (only Voyager 1 has gone farther) and 100,000 times farther than its little 1958 predecessor. (Models of both Pioneers are on display in the Museum, by the way.) As NASA begins to build rockets, spacecraft, and an astronaut corps to return us to the moon (see "Fly Us to the Moon," p. 48), it's a good time to wonder how much more the next round of lunar voyages will accomplish, especially when we recall what the Pioneers achieved after the first glorious failure. What the space program reaches for today wouldn't have been possible if the engineers of the early Pioneer program hadn't had the sand to keep trying.

■ ■ ■ J.R. DAILEY IS THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.



The recent U.S. Mint release of the new \$1 Presidential Coins, some without the motto "In God We Trust," has numismatists digging into the history of the motto. The results revealed not only the first design attempting to use the motto, but led to the exclusive striking of this "lost" design for the VERY FIRST TIME!

America's "Trust In God"

The First Coin Design To Show...

Proposed by James B. Longacre

...and Discovered in a Smithsonian Institution Vault

Unseen for over 140 years! In 1864, America's first attempt to add a religious motto to its coins was rejected. Filed away in the pages of U.S. Mint chief engraver James B. Longacre's sketchpads, the design remained unseen for over 140 years—until now! While studying Longacre's notes stored in the National Numismatics Collection at the Smithsonian Institution, researchers found that the famed designer's first attempt at the motto was actually for a \$20 Gold Double Eagle with the words "Our Trust Is In God." The design was shelved as Congress debated over the inclusion of the motto on U.S. coins. Instead of appearing on a \$20 Gold Double Eagle, the first coin to utilize the motto was Longacre's Two-Cent piece with the motto shortened to "In God We Trust."

Why the shortened motto? Was the motto shortened to accommodate the smaller denomination? We'll never know, but now you can own a pure silver Proof of Longacre's first endeavor to convert U.S. coinage with this magnificent proposed-motto design—struck for the very first time from his actual sketches discovered in the numismatic vault at the Smithsonian Institution! Containing one ounce of .999 pure silver and struck to an ultra-cameo Gem Proof quality, this wonderful design commemorates a piece of American history and belongs in everyone's collection. Now you can secure the world's first and only "Our Trust Is In God" Double Eagle Proof for only \$99 (plus S&H). CALL TODAY!



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Letters

WRITE TO US

Bond's Mysteriously Missing Aircraft

How could the otherwise delightful "Live and Let Fly" (Aug./Sept. 2008) not include the Avro Vulcan in *Thunderball*? Graceful and fast, the delta-wing Vulcan was a definite thumbs-up. The scenes showing the Vulcan's takeoff, hijacking, ditching, and bomb recovery, along with 007's discovery of the ditched bomber minus the special weapons, made the movie.

Reed Petrie
Anchorage, Alaska

How can you forget that in *Moonraker*, Bond is in a Glastron speedboat with an accompanying hang-glider? As his boat goes over the falls, Bond grabs onto the hang-glider and lifts off, saving himself from certain death.

Jesse Benson
Los Angeles, California

Portrait of the Portraitist

Readers of "Portrait of the Enemy" (Aug./Sept. 2008) might enjoy Emily Mitchell's imaginative take on photographer Edward Steichen's role in World War I; check out her first novel, *The Last Summer of the World*.

Dan Verner
via e-mail

Rejecting Vectoring

As early as 1941, my father, Willis Hawkins, then head of Lockheed Aircraft's Preliminary and Advanced Design teams, proposed a vectored thrust system (How Things Work, June/July 2008). The system was intended for the Lockheed L-133 project, the first U.S. attempt at an aircraft with jet propulsion.

There was some concern that the L-133 would require an exorbitant takeoff run, and the teams worked up a number of solutions, including powered wheels and thrust vectoring. When the L-133 was presented to the

Army Air Forces in 1942, the service determined that jet propulsion was not viable, and the first conceptual foray into thrust vectoring died.

Although the original idea was limited to takeoff augmentation, Hawkins expanded it in later iterations to include super-maneuverability.

As a bit of serendipity, my father's last paycheck was drawn against the Lockheed Skunk Works as a consultant on the F-22 Raptor, so he finally got to witness his concept come to fruition on Lockheed iron.

Will Hawkins
Menlo Park, California



COURTESY WILL HAWKINS

Thrust vectoring dates back to the United States' first jet aircraft design, Lockheed's canard-equipped L-133 (simplified model above).

Space: No Friend of Patriotism

"Finding Apollo" (Aug./Sept. 2008) raised a question about the current state of the American flag that the Apollo 11 astronauts erected on the lunar surface. On July 27, 1991, cosmonaut Anatoli Artsebarskiy installed a common acetate-silk flag, one meter by two meters, atop the Mir space station's Sofora girder. Within seven months the flag was severely shredded, and after a little more than a year of exposure to the harsh environment of space, no trace of the flag could be found.

An investigation was undertaken by two Russian and two American specialists (myself included), and we concluded that the principal cause of the loss of the flag was atomic oxygen,

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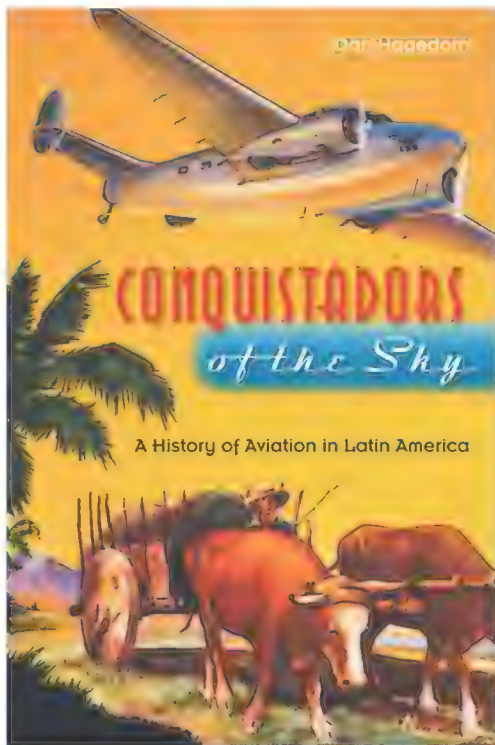
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Letters

with ultraviolet radiation contributing. Although atomic oxygen should not be a factor on the lunar surface, the effects of UV radiation and micrometeoroids over 39 years should have yielded the same result.

Nicholas L. Johnson
Chief Scientist for Orbital Debris
NASA Johnson Space Center
Houston, Texas

Respect for the Dead

The XF-90 ("Lockheed's Missing Link," June/July 2008) was one of the most beautiful airplanes ever built. And it's good that the remains of the only one left have a home.

But displaying the XF-90 exactly as it looked after sitting out in the desert for half a century? That would be as if Madame Tussaud's Wax Museum had set out to honor a world-class beauty who had died in the 1950s, but made a model showing what the woman actually looked like today.

Ron Capek
Waterford, Michigan

Correction

June/July 2008 "Aircraft That Changed the World": The B-29 was the first bomber, not the first aircraft, with a pressurized flight crew compartment.

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*photographed in the Milestones of Flight gallery, National Air & Space Museum,
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Bobbing for Beaufighters

➤➤➤ **IT WAS WHEN** he was surveying a shipwreck that Canadian archaeologist and professional diver Rob Rondeau learned about Black Friday. “I was in Norway in 2005 and was moved when I learned more,” he says.

On the afternoon of February 9, 1945, 32 Bristol Beaufighters lifted off from the Coastal Command base Dallachy in Scotland. The fighters were flown by three squadrons: Royal Air Force 144, Royal Australian Air Force 455, and Royal Canadian Air Force 404. They joined up with 12 RAF Mustangs and turned east over the North Sea to attack a German flotilla, led by the Narvik-class destroyer Z33,



that was lurking in Forde Fjord, Norway. It was to be a surprise attack, but the Allies, facing intense anti-

aircraft fire while maneuvering inside the fjords, were bounced by several German fighters.

Rob Rondeau surfaces with EO-W's tail wheel.

Nine Beaufighters and one Mustang were lost.

Dubbed Black Friday, the event marked the greatest single-day loss of Canadian aircrew—11—and RAF Coastal Command crew in World War II.

Rondeau undertook an expedition to dive for the lost Beaufighters. In February 2008 he located PL-Y from the RAF's 144 Squadron and EO-W from the RCAF's 404 Squadron. EO-W had hit a mountain and tumbled into the fjord; Rondeau managed to recover a tail wheel and a hydraulic tank. With a little sleuthing he learned there were several more Beaufighters he thought he could find. One, UB-O,

UPDATE

Nose Job

While Manhattan's aircraft carrier-turned-museum *Intrepid* was overhauled (“Restoration: Cleaning a Carrier,” Aug./Sept. 2008), the Concorde that had been on display on a barge in the Hudson River was moved to a facility at Floyd Bennett Field in Brooklyn. Last July, a truck navigating the area in the middle of the night accidentally sheared off the supersonic



While in storage, the *Intrepid's* Concorde took a beating.

transport's needle-nose. While various parties bicker over who will pay for the repair, John Lampl, a spokesman for British Airways, which leases the Concorde to the *Intrepid* Sea, Air & Space Museum, notes that Concorde parts are no longer manufactured. However, he says that British Airways knows of collectors who bought spare nose cones at an auction, and says the museum can likely buy one from them. (Flash to nose cone owners gleefully rubbing palms together.)

piloted by RAAF Flight Lieutenant Bob McColl, was to be a particular prize: He had tracked down the pilot's son. The senior McColl had elected to ditch his damaged airplane, which Rondeau says makes for a better wreck. "If the aircraft was ditched successfully, there's a good probability it will still be intact on the sea bed. It floats down like a leaf."

Rondeau was hoping to retrieve McColl's flying boot, left when the pilot hurriedly exited his sinking fighter, during a dive in June, for which McColl's son had flown in. But UB-O was in some 260 feet of water, and Rondeau did not have the diving equipment required for that depth. Nonetheless, late in June a ceremony was held near the Forde Fjord wreck site. Lieutenant Colonel Doug Baird of today's 404 Squadron was on hand, as was Bert Ramsden, at 86 the last Canadian alive who had flown in Black Friday's battle. Particularly excited was a local 70-year-old who remembers watching the epic event as a schoolboy. They paid remembrance to EO-W and presented the tail wheel and hydraulic tank to the Black Friday Museum in Naustdal, Norway.

"This doesn't mean that we've quit looking for UB-O," says Rondeau. They'll be back next June with gear for deeper diving, this time with support from the Norwegian navy and the Australian and British governments. If Rondeau finds the aircraft, he hopes someone will restore it; only two examples of the type exist today.

GRAHAM CHANDLER

No Rush

»»»THE FIRST TIME a zeppelin appeared over London, on May 15, 1915, it dropped bombs on a pub, killing seven. On the most recent zeppelin visit to the city, last June, the airship carried 12 people on an aerial tour. The same airship is now making its way to California, where Brian Hall plans to breathe new life into a business and a vehicle that he maintains is not sooo last century.

"It's a high-tech, cool thing," says Hall, who made a fortune with Mark/Space, a company that develops synchronization software for mobile phones and BlackBerrys. He's quick to add that these aren't quite the same zeppelins that had a bad habit of bursting into flames, as did Count Ferdinand von Zeppelin's LZ.4, which in 1908 exploded at its mooring. When the *Hindenburg* did the same in 1937, it pretty much ended the Zeppelin brand. The company didn't

A Zeppelin NT loiters over London, carrying sightseers for a 60-minute ride.



die, though; it survived as a foundation, which, in the last decade of the last century, started building a smaller, more advanced airship using sophisticated technology. Instead of an aluminum framework, the Zeppelin NT (New Technology) uses triangular carbon-fiber trusses held together with aluminum longerons. And it floats with helium instead of flammable hydrogen. Roughly a third the length of the *Graf Zeppelin*—246 feet, compared with 776 feet—the NT carries a dozen passengers instead of

"Landing" an airship is somewhat like dancing with an elephant.

72. Unlike old zeppelins, it doesn't cruise for days at a time. It's more like a tour boat.

"The sweet spot of sightseeing is an hour," Hall says. By that time, he explains, the airship has reached 1,000 feet and everyone has had a chance to get up and wander around the cabin, check out the controls, and stick their heads out the window. "It takes 45 minutes for people to feel like they've explored



COURTESY STELLA ARTOIS: STAR OVER LONDON (2)

the whole ship and can sit down again.”

A zeppelin can do more than just sightsee: It can take air quality samples, for instance, and one is being used in South Africa for diamond prospecting. The airship can loiter, and, because its engines are mounted on the frame instead of the gondola, there’s little vibration. “You can mount sensitive instruments on it that you can’t on a helicopter,” says Hall. It’s also a fairly quiet ride. “On a zeppelin, you can have a normal conversation.”

Hall became fascinated with old-time aviation as a kid. “Growing up, I went to Old Rhinebeck Aerodrome [in upstate New York], and that kind of started my interest in aviation history,” he says. After Mark/Space, he wanted to start a new business, “looking at old technologies that had not been exploited.” In the mid-1990s, he learned that Zeppelin was starting to build the NT, and after traveling to Germany for a ride, he told his wife, Alex, “We’ve got to bring this to the U.S.” He’s purchased three, all for sightseeing. One will be based at Moffett Field in San Francisco, which was once home of the USS *Macon*—a rigid helium-filled airship that crashed in the Pacific during a storm in 1935. The second will be based on the East Coast, around Lakehurst, New Jersey (where the *Hindenburg* exploded). The third will stand in for the others while they’re down for maintenance.

PHIL SCOTT

Farouk El-Baz

DIRECTOR, CENTER FOR REMOTE SENSING, BOSTON UNIVERSITY

FAROUK EL-BAZ HAS SPENT HIS CAREER interpreting satellite photographs. The Egyptian-born geologist identified science sites for the Apollo astronauts and pioneered the use of space photographs to research desert environments.

In February, you chaired a panel at a conference in Boston discussing engineering challenges for the 21st century. What challenges does aerospace face?

There will be a necessity to know the effects of long-range travel in space. A trip to Mars might take two or three years – but the effects on humans, we don’t know. Many companies [will be] taking people into orbit for short periods, at reasonable cost, so that people can see the Earth from space. People won’t [want to] be subjected to vigorous medical tests. So we want to make sure the equipment would be safe and reasonable on the human body.

There’s been much talk about “carbon footprints,” especially in regard to aviation. How much of an effect does air travel have on the environment?

Aircraft consume a great deal of fossil fuel. But if we would travel on land [across] the [same] distances that are traveled by aircraft, we would definitely have to add more toxic components in the atmosphere, with the carbon signature increasing. So air travel reduces the carbon footprint if we make it available for everybody. But engineers must begin to think about reduction of the amount of fuel that is used by aircraft, especially in takeoff and landing.

How will space travel change in the next century?

There will be plenty more branches for tourism in space for all kinds of varieties. There will be people who go there for less than an hour, and there will be others that would stay for a few days and feel the zero-gravity effects, and maybe others that want to stay for their whole vacation. Space travel in near-Earth orbit will increase a great deal in the next century. In addition, space travel by trained astronauts will increase. China is pursuing that vigorously, and India will be following suit. Japan and the Europeans might have their own long-term and long-range space travel within the solar system.

Is there a place for NASA and other government-funded space agencies in the next century?

Yes indeed. There’s the expense of space exploration for scientific purposes, to collect data about the solar system and beyond. It’s something that actually must continue to be paid for by governments.



El-Baz peers out the porthole of a United Nations Russian helicopter in Darfur, western Sudan.

Distance Flier

»» IF YOU'VE BEEN to your local park recently and heard a buzzing overhead, it might well have been an airplane—one with a 38-inch wingspan. Wings Across America 2008, organized by U.S. Air Force veteran Frank Geisler of Gloucester, Virginia, has signed up over 300 pilots of radio-controlled (RC) models to hopscotch a “park flier”—a model airplane typically flown in public parks or sports fields—across the 48 contiguous states. Each pilot flies the aircraft one time, then carries it to the next pilot on the list. Geisler kicked off the event on Memorial Day weekend

at his local club's flying field, where the airplane took flight for the first time.

Bill Stevens of Stevens AeroModel in Colorado Springs, Colorado, donated the aircraft, a SQuiRT—Simple, Quiet Robust Trainer. Constructed of balsa wood, the model weighs just over a pound. Using a hand-held control, the pilot transmits a signal to the battery-powered motor, which drives the propeller and operates the flight control surfaces.

“I wanted to help publicize the hobby of RC aircraft and to further the camaraderie of RC pilots,” says Marsh DeHart of Chantilly, Virginia. DeHart flew the SQuiRT at his local park on June 14, then



Frank Geisler shows off a SQuiRT that will cross the country.

packed the aircraft in its custom-built travel box and delivered it to Clarksburg, Maryland, where the next pilot was waiting.

Geisler says the sport has something for everyone, from those “flying one-ounce indoor planes to huge jet-powered planes.” The Academy of Model Aeronautics, a nonprofit

association for RC enthusiasts, sanctions about 1,000 competitions annually.

When Wings Across America returns to Virginia next summer, the SQuiRT will have traveled 14,000 miles—an impressive distance for any airplane, no matter what the size.

ALLAN DUFFIN

COURTESY FRANK GEISLER

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In The Museum

STOPS ON A TOUR THROUGH AMERICA'S HANGAR

The Universe in 5,000 Square Feet

"I'VE LEARNED that there are three kinds of museum-goers: streakers, strollers, and searchers," says Roger Launius, senior space history curator at the National Air and Space Museum. The first kind, he says, fly through an exhibit, barely stopping to read anything. The second drag their feet, reading a display here and there. The third take in every panel, every graphic, every word. "Even I'm not in that last category," he says. "But we try to cater to all three types."

He's talking about "Space: A Journey to Our Future," an exhibit in the Museum that dovetails with NASA's 50th birthday, October 1, and runs through January 11, 2009. A traveling, private-sector show produced for entertainment giant AEG by Evergreen Exhibitions with NASA support, it celebrates space exploration, past and future.

At the gallery's entrance, streakers may tend to fade right, into the central, open area, which houses an array of interactive displays. But searchers and strollers will want to head into a passageway that introduces the most basic process in space exploration: how humans leave Earth. Murals detail how rockets obey Isaac Newton's laws of motion, and an interactive screen explains the term "launch window." Another mural reveals a little-known fact about one of the coolest heads in space travel, Neil Armstrong: Just before he and Buzz Aldrin set their

lander on the lunar surface, with 30 seconds of fuel remaining, Armstrong's heart was hammering at 156 beats a minute. Space travel, it seems, gets the juices flowing.

Other elements will quicken the pulse of the armchair astronaut, such as a tire from a lunar rover and a 70-mm Hasselblad camera from Apollo 17. Stand in front of a well-lit photo-mural of a lunar landscape for an I-was-there pose.

The real crowd pleaser is a lunar habitat, offering toys, joysticks, and screens that let you put a lander down

Visitors may design one of two theoretical Mars base camps (below), named Viking or Odyssey, set in the year 2031. They can also enter a lunar habitat (right) for a sense of a permanent pad on the moon.



onto the lunar surface or operate a rover across a desolate landscape. Climb into a bunk, complete with an imaginary moon dweller's family photos from the home planet. In the center of the habitat, an authentic moon fragment beckons with a sign: "Please Touch This Moon Meteorite."

Next door, a 360-degree theater, the exhibit's largest element, puts on a dazzling light and video show about the universe, covering everything from the Big Bang to the formation of galaxies and planets. The narrator challenges each visitor with questions: "Who will be the modern Newton? The new Einstein? Who will unlock the deepest secrets of the cosmos?"

The exhibit can fill 12,000 square

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feet but usually lands in halls half that size. Launius, the exhibit's curator during its stay, distilled it to a little more than 5,000 square feet to fit in gallery 113 at the Museum's east end. With collaboration from NASA, where he was chief historian between 1990 and 2002, Launius added material on the Constellation program, aimed at sending humans beyond Earth orbit. A hefty, quarter-scale model of the Orion vehicle, which will carry astronauts to the International Space Station and eventually to the moon, hangs from the ceiling. In the corner of the gallery stands an imposing 1/34 scale model of the Ares I launcher, developed to lift Orion from Earth. Launius says it's the only Constellation material that the Museum exhibits. An innovative, horseshoe-shaped sensor acts as a computer air mouse; visitors can call up infographics about the program on a large video screen by waving their hands inside the sensor.

The gallery offers plenty of interactive ways to learn, from push-button displays on deep-space probes to scales that tally body weight on Earth, the moon, and Mars. Vivid touch screens fill the room and cover "Space on Earth: How Space Exploration Transforms Our Daily Lives," "Make Your Own Base Camp," and "Pack for



Star Party Join Museum staff astronomer Sean O'Brien on two Saturdays, October 25 (6:15 to 10 p.m.) and November 22 (4:45 to 10 p.m.), in observing celestial objects in skies unpolluted by city lights. Sky Meadows State Park, Virginia. Parking fee: \$4 per car. Park phone: (540) 592-3556.



Docent Tours Docent-led tours highlight the Museum's collection and trace the history of air and space travel. Tours are conducted daily at 10:30 a.m. and 1 p.m. At the National Air and Space Museum on the Mall, meet at the Welcome Center. At the Steven F. Udvar-Hazy Center, meet at the docent tours desk in the Boeing Aviation Hangar.



What's Up Receive regular updates on Museum events, read about artifacts, get detailed (and behind-the-scenes) exhibition information, and receive calendar listings by subscribing to the National Air and Space Museum's free monthly e-newsletter, *What's Up*. Sign up at www.nasm.si.edu.



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the Trip to Mars," in which a computer-generated helper, Ruby Redstone, advises what to bring to the Red Planet: food, water, oxygen, a

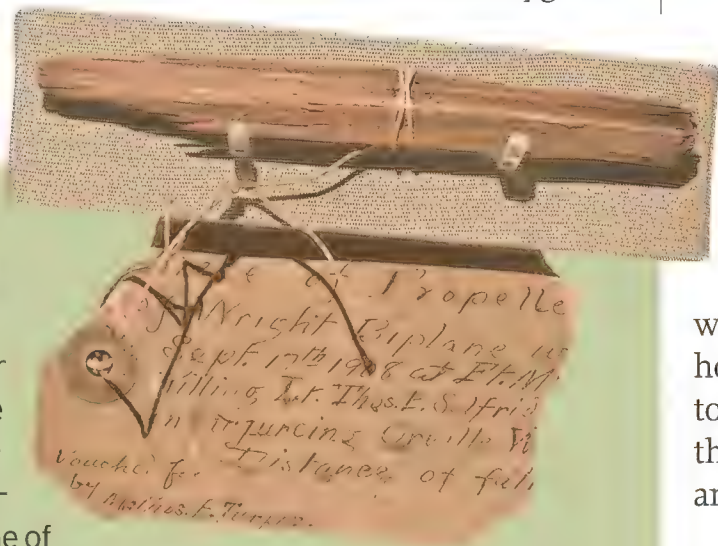
spacesuit. A few steps away, "The Infrared You" features a sensor that detects subtle differences in body temperature and color-codes visitors as they move about. Turn around to another display and learn more about how scientists use infrared radiation to study the universe.

"The interactives are the main strength of this exhibit," says Peter Rudetsky, a content developer who wrote the exhibit's 7,000 words. "I hope adults spend time doing them too. And we put the text in a format that wasn't arduous, so this isn't like an article. It's like a big picture book."

Lockheed Martin, ATK, and General Motors, all sponsors of the exhibit, agreed to forgo corporate displays to preserve the educational spirit of the show. This provided more room to portray the environment astronauts and robots have explored, and those that future ones will. Maybe one of those astronauts is a toddler who left little fingerprints around the exhibit today, and took home dreams of tomorrow.

Airshow Souvenir

WRITTEN IN BLACK INK on a sliver of wood is a single word: "Wright." The handwriting is that of Henry Juene-mann, son of a Capitol Hill lager brewer, and the wood is a fragment from one of the 1908 Wright Military Flyer's propellers. Just four years after Orville and Wilbur Wright's triumph at Kill Devil Hills, North Carolina, the U.S. Army Signal Corps solicited bids for a two-seat observation aircraft; the Wright brothers entered a wire-braced biplane. During air trials at Fort Myer, Virginia, passenger Lieutenant Thomas Selfridge was killed and pilot Orville Wright severely injured when the aircraft crashed after its propeller blade split. It's possible that Juene-mann (whose relatives donated the artifact to the Museum in 1999) was in the crowd that day; family lore says the amateur historian was famous for attending events in and around Washington, D.C.



A fragment from one of the wooden propellers of the 1908 Wright aircraft.

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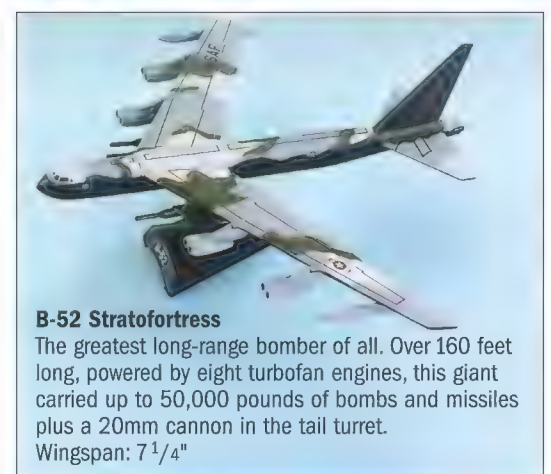
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The Village of Tempelhof

AS A U.S. ARMY INFANTRY

sergeant, I arrived in West Berlin in 1956 on a troop train, but the divided city was open to commercial air travel almost as soon as World War II ended. American Overseas Airlines began service in 1946, flying into Tempelhof airport. A Nazi-era marvel of modern architecture and engineering, Tempelhof features a cable system that suspends a protective roof over the semi-circular arrangement of aircraft arrival gates. Nothing like it had been built before. Construction began in 1936—and is still incomplete.

Raymond Russell, 89, flew for AOA when it started flying to the airport. (AOA was bought by Pan American World Airways in 1950.) He recalls landing on a runway with steel plates here and there covering the bomb craters. Russell, who landed at Tempelhof for the last time on December 14, 1979, says architecture is not the only feature making the airport extraordinary. “Tempelhof was the most unusual because of its location in the center of Berlin,” he says. “This necessitated an approach between apartment buildings.”

The airport’s history also sets it apart. On July 4, 1945, a U.S. Army Air Forces Fairchild C-2 landed at



Prussian West Point, which the Soviet army had occupied since April 28. The Soviet flag was taken down and the U.S. flag went up. Thus began the U.S. occupation of West Berlin.

Tempelhof became famous in 1948 as an early battleground in the cold war. On May 24, the Soviets blockaded Berlin in an attempt to force out the Western allies (the United States, France, and Britain). The three countries responded with the Berlin Airlift, supplying by air West Berlin, an island surrounded by communist

were accredited as part of the U.S. Mission and received a Military Privilege Card similar to one soldiers carried. We had access to all allied military installations, including Tempelhof, which besides being a busy international airport was a military base. Tempelhof created a small, self-contained, friendly village that included in its confines nearly everything one needed for a good life, and where everyone knew everyone else. I had a post office box at the Tempelhof Army Post Office. I played on the Pan Am basketball team (always short-handed) in the Tempelhof lunchtime league.

A jogger, I ran Tempelhof’s inner perimeter. Once, in 1968, I looked up at a landing airplane and saw it had the letters LOT, which stood for the Polish national airline. *Polish airliners are not allowed into Western airspace. Skyjacked!* Still in my jogging clothes I reported the story, which included an interview with the base commander. He had learned that for one of the stewardesses, it was the second

In a 1996 decision that has riled thousands of Berliners, the city’s governing body, a coalition of Socialists and former Communists, announced plans to close Tempelhof.

Tempelhof. The ramp dropped, and off came a Jeep driven by Corporal Terry Mohr of the 82nd Airborne Division. A general exited the C-2 cabin and got in the Jeep. Mohr (who still lives in Berlin) drove through the ruined city to the barracks of Hitler’s *Leibstandarte* (Bodyguard Regiment), formerly the

East Germany. A transport landed at Tempelhof every 90 seconds.

But what made Tempelhof extraordinary to me was its culture. After I was freed from Army service, I became a journalist and stayed on in West Berlin as a reporter for most of the cold war. Journalists in West Berlin

skyjacking to Tempelhof. "If she gets skyjacked again," he said, "I'm going to make her a member of the officers' club." So many skyjacked LOT airliners landed at the airport that the joke around the field was that LOT stood for Land on Tempelhof.

The city's unusual isolation made it attractive to young people from Western Europe and the United States. American kids found jobs at Tempelhof handing out towels in the base gym, waiting tables in the officers'

The 1984 open house at Tempelhof (opposite); the author in the languishing reception hall, 1978 (below).

fighters for display, Pan Am opened an airliner for tours, and the Army dropped paratroopers. American social, charitable, and patriotic groups manned food and beverage stands to raise money. Attendance was regularly over a half-million.

From 1945 to 1990, Berlin remained occupied by British, French, Soviet, and U.S. air and land forces, and it was with their permission the Berliners governed the West and East halves.

Berlin was the focal point of the cold war, and throughout it, some activities continued without interruption, including commercial aviation at Tempelhof. All flights into the city

turned over to them. The allies refused. The French suggested they paint French markings on the airplane and fly it out. Finally, the wings were removed and loaded with the fuselage onto a U.S. transport and flown out—at the expense of the owner.

One Christmas Eve, the tower chief, Sergeant Parker Smoak, passed a "permission to land" request to the allied air representatives. Each officer read, signed, and passed it on. When it got to the Soviet officer, everyone wondered: What would he do? Finally, he shrugged, grinned, and stamped. Permission to land at Tempelhof was granted to Santa and his reindeer.

In 1975, a new airport in the French sector of Tegel opened, and civilian air traffic moved there. Tempelhof languished. It may have been the only U.S. Air Force base that never had an airplane assigned to it. Many of the 500 airmen and -women on the base did intelligence work at a radar post, listening to Eastern Europe. A daily courier flight came in from West Germany. Occasionally a Military Air Transport Service airplane arrived from South Carolina. The field was mostly used by the Army helicopter unit patrolling the Berlin Wall.

The 1990 reunification of Germany ended the Pan Am-British Airways-Air France monopoly on Berlin. Small carriers were permitted to fly to Brussels or Sylt, a popular German vacation island in the North Sea. The U.S. flag at Tempelhof came down in the summer of 1994.

In a 1996 decision that has riled thousands of Berliners, the city's governing body, a coalition of Socialists and former Communists, announced plans to close Tempelhof. But the opening of the replacement airport, Berlin-Brandenburg International (the old Communist airport at Schoenefeld), keeps being postponed, and overruns have doubled the original estimate of 500 million Euros (about \$750 million) for the opening. On October 31, the last airplanes will land and take off from Tempelhof.



club, and washing dishes in the enlisted men's club. Twenty hours a week earned them the treasured Military Privilege Card, which permitted the bearer to place on his or her car an American Forces license plate. Cars bearing this plate could not be searched by the Communist People's Police on the other side of Checkpoint Charlie, the crossing point used by foreigners and the allied forces. Several card holders earned large sums by smuggling people out of East Berlin in their trunks.

Annually, Tempelhof threw West Berlin's most popular party: a two-day open house. The Air Force flew in

were monitored by representatives of the three allies and the Soviets. Private aviation was forbidden, and only airlines of the Western allies could provide service to West Berlin (Pan Am, British European Airways, and Air France, as it turned out).

When a West German pilot flying his small airplane from southern to northern Germany was blown off course by a storm, he landed at Tempelhof—which was illegal, as was his flight over East Germany (and you can bet East German and Soviet air defense heads rolled). While the pilot was free to return to West Germany, the Soviets demanded the airplane be

Oldies & Oddities

FROM THE ATTIC TO THE ARCHIVES

The *Alraigo* Incident

TWENTY-FIVE YEARS AGO last June, the Spanish container ship *Alraigo* was steaming off the coast of Portugal on its way to Tenerife in the Canary Islands. Not far away, aboard the British aircraft carrier HMS *Illustrious*, which was participating in a NATO exercise, 25-year-old Sub-Lieutenant Ian “Soapy” Watson was preparing for his 14th sortie in the Sea Harrier vertical-takeoff-and-landing jet. Watson was paired with a more senior pilot in another Harrier and ordered to find a French aircraft carrier. Simulating combat conditions, the two departed under radio silence and with radar off. They split up when they reached their search area, climbed to assigned altitude, turned on their radar, and swept separate zones.

Search completed, Watson descended and headed to the point where he was to rejoin the flight leader. When the leader didn’t show, Watson relied on his inertial navigation system to get him back to the *Illustrious*. “I went through everything I had in the airplane to help me,” he said. “I tried the radio. I had the radar on. I squawked emergency. Absolutely nothing. There were no returns on the radar.”

Knowing that shipping lanes lay off the coast, Watson turned east. When his radar began showing a target, Watson turned toward it. At 50 miles out, running low on fuel, he was down to only a few minutes of flight time. At 12 miles, Watson caught sight of the *Alraigo*. His plan was to make sure the ship saw him and then eject.

With no way to communicate with the ship, Watson did a flyby “to get their attention.” As he flew alongside, Watson saw that some cargo containers formed essentially a deck, one similar to a landing pad he had



used during training. “Well, I thought, *in for a penny, in for a pound*, and I landed the airplane on the containers.”

As Sea Harrier ZA 176 settled on the slick containers, it began sliding backward. Watson tried to retract the landing gear. The main gear dropped off the back edge of the container. A delivery van on the ship, en route to a florist shop in Tenerife, suffered a blow as the rear of the Sea Harrier hit the deck. The captain of the *Alraigo* refused to let the drop-in visitor throw him off schedule: The British government was informed that Watson and the jet would arrive in Tenerife in four days.

When the *Alraigo*, with the jet atop the containers, docked at Santa Cruz de Tenerife, a horde of reporters was on hand. The ship’s crew and owners filed a salvage claim and were awarded some £570,000 (\$1.14 million at the time) as compensation for the “rescue.” When Watson returned to the *Illustrious*, a Board of Inquiry essentially did nothing. But when the

Sea Harrier landing. THAT’s gotta hurt.

Illustrious returned to port, Watson underwent a second Board of Inquiry.

In 2007, Britain’s National Archives released a number of Royal Navy files, and the second inquiry report was finally made public. Noting that Watson had completed only 75 percent of his training before he had been sent to sea, the board blamed Watson’s inexperience, and his commanders for assigning him an airplane “not fully prepared for the sortie,” a reference to radio problems. Nonetheless, Watson was reprimanded and given a desk job.

Watson eventually acquired 2,000 hours in Sea Harriers and another 900 in F/A-18s before resigning his commission in 1996. Today, he says that media attention embarrassed Royal Navy brass and caused the punishment, but refuses to point fingers. “It was me,” he says. “I was there and that’s where it should stop.”

TIM WRIGHT

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AIRLINER REPAIR, 24/7

Boeing's traveling fix-it team has one goal: Get it airborne.

by Stephen Joiner



JIM TESTIN, DIRECTOR OF AIRLINER REPAIR SERVICES at the Boeing factory in Everett, Washington, made a prediction in July 2007 based on 27 years of experience. "I can tell you this: Something will always happen on Christmas Eve," he said with the certainty of a man who has missed many family gatherings.

Five months later, on the night of December 24, a tow tractor pushed a Boeing 767 away from the gate at a busy European airport. And pushed. (*Air & Space* agreed not to publish the name of the airline or any location.) Passengers heard "a very loud noise" and were invited to disembark via roll-away stairs. An ocean and a continent away, at Boeing's Commercial Airplanes Operations Center in Seattle, an immense video screen displayed the status of the airliner shoved tail-first into a 14-foot blast-diversion fence. It was officially AOG—Airplane On Ground. For an airline with tickets to sell, that is exactly where you don't want an airplane that can earn more than \$200,000 a day.

From the dents and dings incurred on crowded taxiways to a jumbo jet bobbing in a Tahitian lagoon, Boeing AOG teams have seen and repaired it all. On call 24/7/365, ready to go anywhere around the world, Jim Testin's quick responders keep over 12,000 extravagantly complex airliners airborne.

"We're not bashful about promoting our ability to do that," he says. "When we have a product that's down and losing revenue, our number-one thing is to get that plane back into service."

The Boeing team isn't called in for everything. Airlines have incidents every day, Testin says, and most airport ground crews can handle routine repairs—a window cracked by a bird, a component failing calibration. An AOG intervention is required for the big things: an airplane off the end of a runway, landing gear accidentally retracted, a flaming tail drag, two 150-ton behemoths kissing wingtips on the ramp.

The AOG team is the most expensive roadside service on the planet. One call activates hundreds of people on a single wavelength: urgency. "I've been on calls where I could still hear the sirens of the emergency equipment in the background," Testin says. Another aircraft might be rushed out of routine maintenance or temporarily diverted from another route to fill in for a disabled airliner. But in the house of cards that is today's airline schedule, yanking even one aircraft from service can cause delays and cancellations.

From an office complex secluded behind tall evergreens on the Duwamish River, the Seattle operations center keeps tabs on Boeing airliners grounded around the world. "In a hospital analogy, this is the emergency room,"

TIM DE GROOT/AIRTEAMIMAGES

PHOTOGRAPHS: RICK TURNBAUGH/BOEING CREATIVE SERVICES



OLIVIER CORNELOUP (3)



An airliner earns only when it flies (top), so repair calls are urgent business. When an airliner struck a blast fence last December, Boeing's on-site maintainers flew to the rescue. The airliner's logo has been obscured to meet the conditions Boeing set for access to the site.



says center director Bruce Rund. It looks more like a downsized mission control. Concentric rows of consoles and monitors accommodate 30 controllers, project leaders, and engineers. On a 30-foot-wide video display, the sunrise is tracked across a world map in one screen. In another, blue icons representing AOGs in progress advance along a timeline, turning yellow, then red, as they approach the center's deadline for action within 24 hours. Controllers conduct telephone triage to establish the severity of each situation and whether the airline wants a permanent repair or a temporary fix that will get the aircraft home. "We need to know quickly: How AOG are you?" Rund says. "Are you sitting in a gate with passengers loaded, or is this problem something you found during an overnight inspection?" The center defines an AOG as any incident requiring a response in less than 24 hours. But when carriers major and mi-

nor queue for critical care, everybody knows who goes to the head of the line: "Whoever's got passengers on board," Rund says. "It's understood throughout the industry that we always look at those scenarios first."

Rund's staff takes 125 calls a day, and by the time an airline calls, it's usually tried everything it can to fix a problem itself. The heavy morning departures in Europe and the afternoon rush in the Middle East create problems that show up during Seattle's witching hours. "It gets really interesting in here when it's 2 a.m. and we're the only game in town," Rund says.

And increasingly they are. As airlines downsize workforces, a busted airplane far from its corporate hub may not be swarmed by a phalanx of mechanics in company jumpsuits. Sometimes, says Rund, "There's one avionics guy with a screwdriver."

The traveling team uses a capacious Antonov An-124 to transport its repair shop (top). Left to right: Damaged pressure dome (at left) and replacement; Randy Pratt works on wiring; planner Bill Reich confers with electrician Craig Oppedal.

Owners of damaged airliners occasionally call with a one-item wish list. "They just want to know if they can fly the plane without doing anything," Rund says. He cites an airline maintenance director pressing for flight approval after sustaining a hammering in a hailstorm. Boeing engineers determined that wing components were damaged beyond limits. Ten minutes of a carefully worded reality check, plus an offer to rush replacement parts to the site, persuaded the impatient carrier to fix instead of fly. "Part of our job is to be the voice of reason," Rund says.

Incident reports advance to the center's

resident engineers. With broad experience across the aircraft types in Boeing's fleet, these frontline troubleshooters huddle to prescribe the most immediate relief. In cases of structural damage, which make up 60 percent of the calls, the solution usually involves collaboration with specialized engineers elsewhere in the company—what Rund terms “the brain surgeons.”

“We get the customer on the line, we get the brain surgeons of Boeing on the line, and we sit in a collaboration room and videoconference,” he says. Plasma screens with smart boards facilitate sketches on digitized blueprints and photos. By now, an AOG survey team in Washington State has been alerted and is standing by. After each engineer confirms his understanding of the damage and votes a course of action, the plan is presented to the airline.

“THIS, BY FAR, IS THE BEST job in Boeing,” AOG mechanic Bernie Dalien shouts over rivet guns and rock ‘n’ roll. “The boring, the mundane, the everyday thing—that’s not our gig.”

We’re in an enormous halogen-lit hangar in Western Europe, standing between two separated segments of a 767. Earsplitting music thunders from an iPod boombox. Widebody X is the one recently spindled on the fence.

As the last of its deplaned passengers straggled to their destinations, the AOG

lated. Back in Everett, a contract is drawn up that includes a firm price. “And the customer either says yea or nay,” Amrine says. In the death match of airline competition, the yeas usually have it.

The reckoning takes into account more than just the repair. A critical shortage of “lift”—the pool of aircraft on the market to replace one scrapped—is a big factor. The waiting list for most Boeing models is three years, and used airliners for sale or lease are scarce. “The book value of the plane, plus the fact that you can’t get a

“Whoever’s got passengers on board, it’s understood throughout the industry that we always look at those scenarios first.”

—BRUCE RUND, DIRECTOR, SEATTLE OPERATIONS CENTER



Blue tape on the fuselage indicates damaged areas. At first glance: not too bad. But the crucial rear pressure bulkhead was punctured, which necessitated splitting the airplane in two.

Order is supplanting chaos. Just getting the aircraft into Boeing hands has a therapeutic effect on stressed-out airline execs. It’s also a healthy antidote to denial when damage is severe. “By this point, in most cases the airline recognizes that—and will tell us—‘This is beyond our capabilities,’” Rund says. “Then it’s time to get Jim’s team involved.”

survey team was en route. The four-member first wave is often in the air from Seattle on just four hours’ notice. Says Paul Amrine, quality assurance supervisor on this project, “Sometimes we go to work in the morning and end up having to ask our wives to bring us a packed suitcase.” Amrine himself arrived at the hangar after back-to-back surveys of incidents in Shannon, Ireland, and Taipei, Taiwan. The team appraises the aircraft, documenting what Boeing calls “discrepancies” (a torn-off wing, for example). Man-hours, parts and resources, and a time-flow to a rock-hard completion date are calcu-

lated. Back in Everett, a contract is drawn up that includes a firm price. “And the customer either says yea or nay,” Amrine says. In the death match of airline competition, the yeas usually have it.

Up on a hangar balcony, a smattering of airport office workers watch the drama of deconstruction. “Most people have never seen a large aircraft come apart like this,” says Mike Carpenter, project team leader. But looky-loos glimpse only airplane-incognito-on-ground. Among the first implements of an AOG team is brown paper to mask identifying airline logos on the airplane during repair. Boeing maintains doctor-patient confidentiality with customers not eager to have their brand name associated with an embarrassing incident—much less advertise the fact that passengers will be boarding an airplane that lately has been in two pieces.

Photos of the incident conveyed only skin-deep gashes on the underside of the empennage. I’d seen as much inflicted on cars in mall parking lots. But the survey team recognized that this was no mere panel-bender. “Just by the external location of the damage, we pretty much knew what to expect,” Paul Amrine says. For a ground-handling incident, it could hardly have been worse. A fence stanchion penetrated at the precise spot to puncture one of the largest, most critical components on an airliner: the rear pressure



“This, by far, is the best job in Boeing. The boring, the mundane, the everyday thing — that’s not our gig.”

—AOG MECHANIC BERNIE DALIEN

bulkhead. The 16-foot-diameter dome-shaped aluminum barrier is sandwiched between the fourth and fifth fuselage segments and seals in life-supporting cabin pressure. These bulkheads are constructed as integral units, so when they are substantially damaged, they must be replaced, not repaired. The instructions have only three steps. Pull the \$120 million airliner completely in two, insert bulkhead, put halves back together again. In three weeks.

Spread across the hangar floor is a half-acre of cranes, jacks, crates, and tool cas-

es. “This is our portable factory,” says Mike Carpenter. The gear, all on casters or pallets, is designed for transit, rapid setup, and tear-down. Once the contract is signed, the AOG operation’s second wave—the mechanics, engineers, and inspectors, plus the portable factory and a cargo hold of parts—descends en masse.

“I’ve got to get 36 people and all logistics on site in a matter of days,” Carpenter says. He picked his team from AOG staffs at the Washington facilities (another small group in Long Beach, California,

tends the McDonnell Douglas fleet). Some have expertise specific to the 767, “but most can work on any Boeing plane any time,” he says. “Structure is structure.”

AOG team accommodations range from tents beside dirt runways in underdeveloped countries to a blur of bland airport hotels. Anniversary and birthday no-shows, chronic jet lag, continual room service sandwich platters—all part of the job.

It’s not for everyone. Within Boeing’s rank-and-file, Testin’s group tends to be conspicuous as self-directed overachievers. “The cream of the crop,” Bernie Dalien says bluntly. “There’s a lot of animosity toward us in the factories because AOG is so difficult to get into. A ton of guys back there would love to have this job.”

Dalien would know. On the arc to AOG, he paid a decade of dues on the 737 and

Opposite: Fred Chadwick and Ron Beatty (foreground) install Cleco temporary fasteners that hold the skin in place for riveting. Below: Beatty machines new parts while Mike Langston manages the tool inventory. Bottom: The team tackles an injured 737 in Turkey.



One of the team's biggest jobs was a 747 that apparently had seaplane aspirations. It ran off a runway in Tahiti in 1993 (right).



BOEING MEDIA (2)

757 production lines, accumulating skills like merit badges. Boeing's average production employee carries seven job certifications; the average AOG member, 28. A competent electrician in Washington you may be, but in AOG you'll also need to drive a rivet and drop an engine with the best of them. And play nice with your fellow Type A's. Candidates for a vacancy are sent on tryout repairs to far-flung locales, not only to test their skills but also to gauge how they relate to others in the tight-knit team. "They'll bring us a guy who really shines in the factory," Dalien says. "But take him out of his comfort zone and put him in a situation like this, and you find out his personality's not cohesive with the rest of us. So he's weeded out."

Nor is an AOG career designed for your inner nine-to-fiver. "We work two 12-hour shifts, around the clock, seven days a week, until we're done," Jim Testin says. "We don't take holidays. My first 11 years in AOG, I missed Christmas nine times." He pauses to tally the number of passports he's filled—six—then shakes his head. "I told my wife I would only do this for three years."

Still, for an average of just one opening per year, Testin gets as many as 500 applicants. Part of the draw is the mystique. Some of the feats the Boeing AOG operation has performed are commercial aviation legends. In 1988, a 747 aborting a takeoff bellied into a mud flat adjacent to New Delhi airport. Fully 70 percent of the airplane required AOG repair or re-

placement, at a total cost of \$75 million. Then a mechanic, Testin worked 126 days straight in a circus-size tent dubbed the New Delhi Dome. Boeing returned the resurrected jumbo as pristine as one just off the assembly line. Two decades later, it's still flying.

As it turns out, pulling a 767 in half is a straightforward procedure. "Everything about these aircraft is designed to be taken apart," mechanic Fred Chadwick says. Before the tail section could be separated from the rest of the fuselage, the towering vertical stabilizer had to be removed. Overhead clearance in the hangar was three feet short, but resourceful AOG mechanics hyper-extended the airliner's nose gear to tilt the tail down. A gantry crane hoisted the enormous fin to within inches of the rafters, then shuttled it over the airplane and lowered it to a jig on the floor. The tightness of the quarters made it a hold-your-breath procedure that dragged through an entire shift. But AOG tool engineer Jason Lockwood was over his first hurdle.

"When they told me I was going to be on this job, I didn't sleep for a month," he admits. Lockwood designs and directs heavy lifting operations. On this repair, heavy lift included the startling act of removing the 48 section—the unwieldy 12,000-pound final fuselage segment that includes the vertical fin, the horizontal stabilizers, and the damaged pressure bulkhead. A 48 separation was a career first for Lockwood. "I'd seen the videos of all the things that can go wrong," he says.





Arnie Larson ensures that commands are transmitted to control surfaces. Craig Oppedal oversees the final pressure test before the airplane returns to service.



Just aft of the rear lavatories, the 48 section meets the 46. At a join ring encircling the fuselage, the two fifths of the airplane are held together by 200 bolts—heat-treated, aircraft-grade fasteners (though they look unsettlingly similar to some you might have in a coffee can in the garage). A cable yoke descended from the ceiling crane and attached at five lift points on the tail section. After the crane applied 12,000 pounds of lift, the bolts were removed in a pre-determined sequence. Since the cable tension matched the section's weight, "theoretically, we should just be able to take out all the bolts and the section will just sit there," Lockwood says. In practice, determining the suspended segment's exact center of gravity required some fine-tuning. A few bolts were left loose but threaded as final tweaks were made to the pitch of the yoke. "Once we've convinced ourselves it's in a neutral attitude," Lockwood says, "we take out those last bolts. Hopefully, it just hangs there." If it pitches, binds, or pendulums, it could damage the precisely machined mating surfaces of the sections.

With barely a twitch, the fuselage demated. The crane backed off, bearing the 48 section, exposing the ruptured bulkhead, and providing mechanics in the now-gaping 46 with a view you hope you never get on your way to the lavatory.

Lockwood slept better thereafter. "It's actually easier to put it back together than it is to take it apart," he says.

The intimacy with the way Boeing air-

planes dismantle now influences how they're built. "We put three AOG team members on the 777 design teams, and we've followed that up on the 787 and the next-generation 737," Jim Testin says. Specific design changes were integrated to minimize damage in common incidents and expedite AOG repairs afterward.

Still, damaged aircraft rarely go back together exactly as they rolled out of the factory. Change—as routine as replacing a stripped bolt with an oversized substitute—happens. "Any time you change the configuration of anything in the structure, you have to document it," Craig Oppedal says. Every deviation from "drawing config," the blueprint gospel of an aircraft as originally constructed, is subjected to his scrutiny and triggers a Field Rework Record (FRR). Oppedal's been on AOG repairs that produced just a few FRRs, and others that resulted in 280. But there's always something. All FRRs become part of the voluminous documentation that follows an airliner around for life.

The replacement pressure bulkhead has no deviations to document. In 1978, a Boeing AOG team repaired the bulkhead of a Japan Airlines 747 damaged in a tail-drag incident. Seven years later, the repair failed in flight, resulting in an explosive depressurization that tore off the

Above: Removing the vertical stabilizer was a hold-your-breath task. Right: Workers test-fit the 16-foot-wide replacement pressure bulkhead.



vertical fin and severed all hydraulics systems. Some 30 minutes later, the aircraft slammed into a mountainside; 520 people died in the second worst airline disaster in history. Investigators determined that the AOG repair did not comply with Boeing's own *Structural Repair Manual*. Boeing accepted 80 percent of the liability for the crash, while JAL accepted the remainder for neglecting signs that the repaired bulkhead was weakening.

Every night at 7:30, the day crew logs out and the second shift "ties in." The playlist mellows, and reassembly continues around the clock. Mangled skin is replaced with new aluminum. The new bulkhead is sealed into the 48 section,

fuselage segments are reunited, and the vertical fin is dropped back into its slot.

The critical task of reconnecting the control cables and hydraulics that operate the tail's rudder and elevators belongs to rigger Randy Pratt. He's required to adjust the 175-foot tungsten steel cables back to Boeing factory specs to produce the flying characteristics the airplane came off the production line with—no matter how far out of whack the airline flew it. "They'll say 'Hey, what did you do to my airplane?'" Pratt tells me. Adjustments made for the flight preferences of particular pilots, or an accumulation of skin patches that skew the airplane's aerodynamics, produce differences from man-

ufacturer's suggested settings. Soon after recouping their airplane, airline mechanics typically set about undoing Pratt's precision work, adjusting cables and neutral positions to customize control to taste.

On day 18 the airplane is towed out into a squall of rain and snow. "We've got a page and a half of functional tests to do," Mike Carpenter says. Control surfaces aft of the separation point are actuated and electrical components energized. The auxiliary power unit then over-pressurizes the fuselage for the "high-blow" test. Made of expandable, credit-card-thin aluminum, the pressure bulkhead in normal service holds seven pounds per square inch. In addition to testing the join ring seal, the 12-psi high-blow stretches the new bulkhead's elasticity nearly to its limit. The test also results in instant break-in: Stretching and fatigue during routine lower pressurizations are thus minimized.

It's day 20, and make-readies continue down to the last minute. At a sit-down with airline officials, every item on the survey list is verbally closed out. Mike Carpenter and Paul Amrine sign their names to a document attesting that the aircraft has been repaired to the standards of the Boeing Company and the Federal Aviation Administration (FAA standards are published online; the AOG team references them constantly) and is ready to return to service. Then the whole movable factory packs up.

Like *now*. "We've literally had passengers with tickets in their hands looking out the window of the gate at us as we were boxing up our equipment to leave," Jim Testin says.

Corporate carriers with three-figure fleets and thousands of flights daily rely on Boeing's AOG teams to discreetly get airplanes flying again, ASAP. But its real clients show up in ones and twos, clutching boarding passes and tripping over shoelaces untied for security checks. "There's a tremendous effort that's put forth on behalf of the traveling public," Testin told me back in Everett, "to make these planes the safest in the world. If an airline calls, we'll have somebody there."

At the operations center, when I suggested that future airliners made of advanced impact-resistant materials might never become tomorrow's AOGs, Bruce Rund had a prediction of his own. "Somebody will figure out a way." ✈

“We’ve literally had passengers with tickets in their hands looking out the window of the gate at us as we were boxing up our equipment to leave.”

—JIM TESTIN, DIRECTOR OF AOG SERVICES



TOP NASA PHOTOS OF ALL TIME

**50 INDELIBLE IMAGES FROM THE FIRST
50 YEARS OF SPACEFLIGHT.**


BY THE SPACE HISTORY DIVISION, NATIONAL AIR AND SPACE MUSEUM

ON THE OCCASION OF THE 50TH ANNIVERSARY of the National Aeronautics and Space Administration, which began its operations on October 1, 1958, we offer this list of the 50 most memorable images from NASA's history. We recognize that any such ranking is inherently subjective. The rationale for why any one image ranked two slots higher than any other combines several factors, including our attempt to balance the list between human spaceflight, satellite imaging, and planetary exploration. Many wonderful images did not make the final cut—we couldn't convince the editors to give us 20 pages instead of 10.


The list omits significant events from space history that were not NASA achievements, such as the famous 1958 photograph of Wernher von Braun and the other architects of the Explorer 1 satellite celebrating their success by holding a model of the satellite over their heads, an event that occurred months before NASA existed. Photos from the Apollo moon program predominate, as well they should—it remains the agency's crowning achievement. We also recognize that, even though the first "A" in NASA stands for "aeronautics," our list is light on aeronautical breakthroughs (see *Moments & Milestones*, p. 84). Our only excuse is that the ranking reflects the affinity of the division of space history staff for space topics.

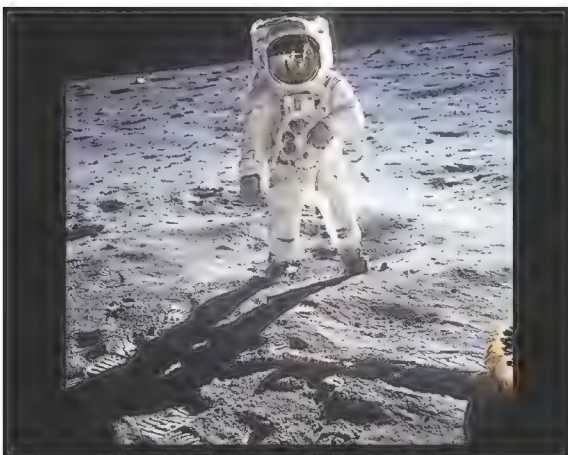
We welcome the discussion we know this list will spark. Debating which images should or shouldn't have been ranked, and how high, would be an appropriate way to mark the past half century of NASA's accomplishments.




1  **WHOLE EARTH FROM SPACE, 1972** Arguably the most influential image to come out of the American space program. Used significantly by the environmental movement (although not, as often reported, the inspiration for Earth Day). Satellites had returned images of nearly the whole Earth before, but this one from Apollo 17, with its view of Africa, the Arabian Peninsula, and the Antarctic ice cap in sunlight, had a more lasting impact.




2  **EARTHRISE, 1968** *The Last Whole Earth Catalog* described this image as: "The famous Apollo 8 picture of Earthrise over the moon that established our planetary facthood and beauty and rareness (dry moon, barren space) and began to bend human consciousness."



3  **BUZZ ALDRIN ON THE MOON, 1969** The best photo of the first humans on another heavenly body. (Neil Armstrong is reflected in Aldrin's visor.) Reproduced worldwide, silk-screened by Andy Warhol. So iconic that many depictions of astronauts reproduce the bent arm – without knowing why.



NASA/EUROPEAN SPACE AGENCY/STSCI/JEFF HESTER, PAUL SCOWEN

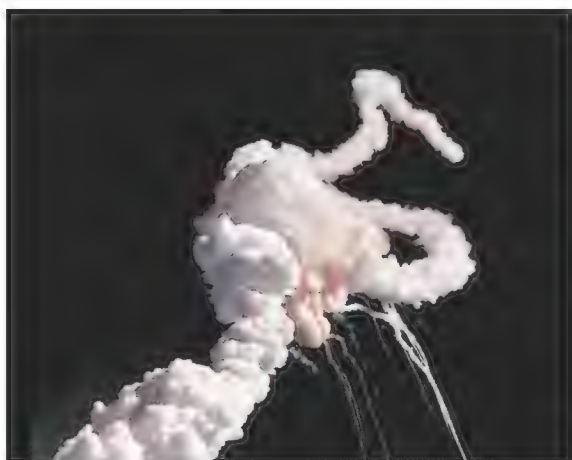
4  **"PILLARS OF CREATION," 1995** Probably the most celebrated image taken by the Hubble Space Telescope. This color-enhanced view of a star-forming region in the Eagle Nebula is a scientific data trove and an aesthetic masterpiece.

ALL PHOTOGRAPHS: NASA

5 > GEMINI 4 SPACEWALK, 1965 First American spacewalk (Russian Alexei Leonov beat Ed White by three months) and first photographs of a person floating in space taken by another person in space.



6 v BOOTPRINT ON THE MOON, 1969 Photographed by Buzz Aldrin, in accordance with Apollo 11 mission objectives, as a way for scientists to investigate the properties of the lunar soil. Stands as the classic image representing human presence on the moon.



8 ▲ CHALLENGER (STS 51-L) EXHAUST TRAIL, 1986 The destruction of the space shuttle *Challenger* 73 seconds after liftoff on January 28, 1986. An image that is instantly recognizable to millions who saw the event played over and over again on television.



7 ▲ "PRESIDENTIAL PANORAMA" ON MARS, 1997 The Sojourner rover (left of large rock) as seen from the Mars Pathfinder lander (foreground). Created expressly to present a high-quality panoramic image to the U.S. President (Bill Clinton), the picture was stitched together from multiple photographs.



9 < JUPITER'S GREAT RED SPOT, 1979 Voyagers 1 and 2 both photographed Jupiter during flybys in 1979. The Great Red Spot, an ancient storm so large that three Earths could fit inside it, had been photographed from Earth before, but never in such detail.

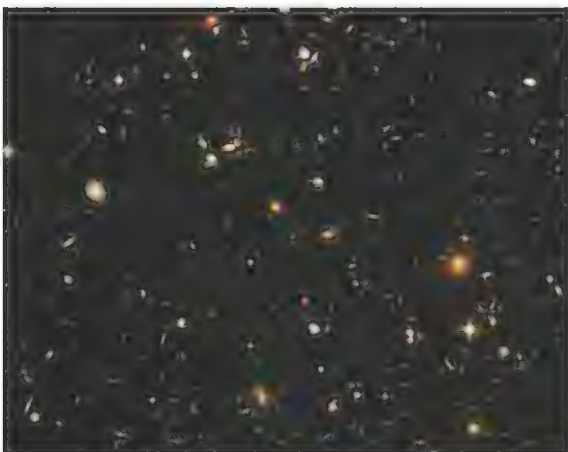


10 ◀ SATURN V LAUNCH, 1969
Liftoff of Apollo 11. Among the best known photos of the giant rocket.

11 ▶ FIRST STEP ON THE MOON, 1969 An estimated half billion people experienced it this way: in black-and-white, on television.



12 ▶ MERCURY ASTRONAUTS
The "Original Seven," as they came to be known, were all male, and all military test pilots. Only one – Alan Shepard (back row, far left), the first American in space – made it to the moon, on Apollo 14 in 1971.



13 ▲ HUBBLE ULTRA DEEP FIELD, 2004 The deepest (most sensitive) view ever taken of the night sky in visible wavelengths. The million-second exposure, taken over the course of 400 orbits by the Hubble Space Telescope, shows more than 10,000 galaxies.



14 ▶ UNTETHERED SPACEWALK, 1984 Bruce McCandless II ventured more than 300 feet from space shuttle *Challenger* in his jet-powered Manned Maneuvering Unit during mission STS 41-B. The first untethered spacewalk in Earth orbit.



#13: NASA/ESA/STSCI

15 ▼ PRESIDENT NIXON VISITS APOLLO 11 CREW, 1969 John F. Kennedy started the Apollo program, but it was Richard Nixon who greeted Neil Armstrong, Michael Collins, and Buzz Aldrin (left to right) in quarantine on board the recovery ship *Hornet* upon their return from the moon.



16 ◀ IRWIN AND FLAG AT HADLEY BASE, 1971 One of Apollo's primary goals was boosting America's image as a technological superpower. James Irwin and David Scott's Apollo 15 mission was the first to carry a four-wheel rover, which allowed for more extensive exploration.



20 ▼ SKYLAB ORBITAL WORKSHOP, 1974 NASA's first space station, Skylab, was almost an immediate failure. The first crew, led by Pete Conrad, saved the mission by installing a sunshade to replace a meteoroid/sun shield that had torn off during launch.

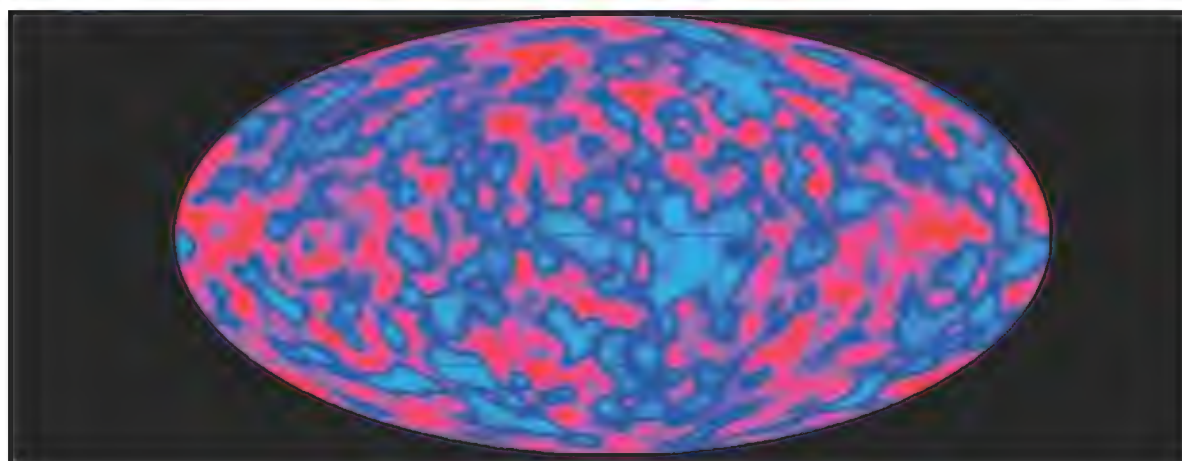


17 ◀ EARTH AND MOON, 1977 Thirteen days after launch on September 5, 1977, on its way to Jupiter, Voyager 1 looked back and took the first-ever long-distance picture of the Earth and moon together. (The moon has been artificially brightened.)



18 ▼ MICROWAVE BACKGROUND, 1992 The Cosmic Background Explorer is the only NASA project to earn a Nobel Prize (in 2006) for its principal scientists. Among COBE's results was this map of the cosmic microwave background left over from the Big Bang.

19 ▲ FIRST PHOTO ON MARS, 1976 On July 20, 1976, seven years to the day after Neil Armstrong stepped onto the moon, Viking 1 made the first landing on Mars. The robot spacecraft's first picture was of its own footpad, just minutes after touchdown.





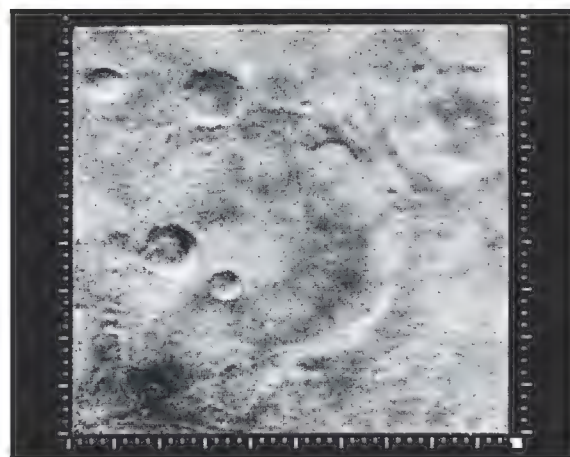
21 ◀ SALLY RIDE, STS-7, 1983
The first American woman in space. Selected to fly on the space shuttle's seventh mission, Ride was one of six women selected to become astronauts in 1978, breaking a two-decade-long tradition of an all-male corps.



22 ▲ APOLLO 1 FIRE, 1967
The first fatal U.S. space accident, and the first serious setback for NASA's moon program. Ed White, Gus Grissom, and Roger Chaffee died during a ground test, when a spark ignited a fire in their sealed, oxygen-rich Apollo command module.



24 ◀ KENNEDY COMMITS TO THE MOON, 1961 President John F. Kennedy's call for a moon landing "before this decade is out" on May 25, 1961, was a gamble. At the time, U.S. human spaceflight experience consisted of Alan Shepard's lone 15-minute flight, three weeks earlier.



23 ◀ X-15, 1960 The X-15 made 199 flights to the edge of space between 1959 and 1968. Among its pilots was a young Neil Armstrong.

25 ▶ GLENN IN ORBIT, 1962
Ten months after Yuri Gagarin, John Glenn orbited Earth – and returned a national hero.



26 ▲ CRATERS ON MARS, 1965
The first close-ups of the Martian surface, taken by the passing Mariner 4 spacecraft, were a disappointment to those hoping to see signs of life. The photos showed a dead, cratered surface.

27 ➤ SATURN 1 LAUNCH, 1965

The Saturn rocket team included many German émigrés, most of them at the Marshall Space Flight Center in Alabama. Among those watching a launch at Cape Canaveral on May 25, 1965, are Kurt Debus (pointing, center), Wernher von Braun (to his left), and Eberhard Rees (leaning).



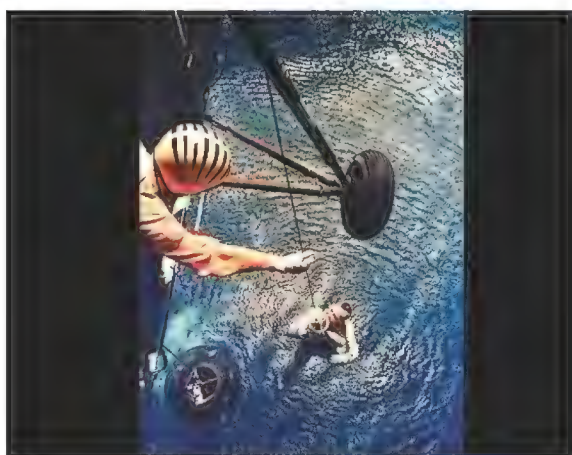
28 ▲ APOLLO 13, 1970

It wasn't until they photographed their abandoned service module before reentering Earth's atmosphere that Apollo 13 astronauts Jim Lovell, Jack Swigert, and Fred Haise saw the extensive damage resulting from an onboard explosion that kept them from landing on the moon.



29 ◀ FIRST SPACE SHUTTLE LAUNCH, 1981

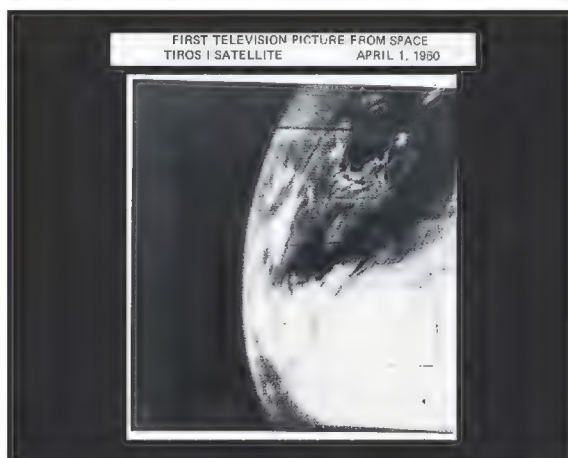
Shuttle *Columbia* lifts off with John Young and Robert Crippen on board, April 12, 1981. The shuttles have carried more people into orbit than all other space vehicles combined, and are still flying 27 years later.



30 ◀ ALAN SHEPARD, FREEDOM 7, 1961 Launched east from Cape Canaveral, Florida, on a short suborbital hop, Alan Shepard, the first American in space, "splashed down" for an ocean recovery by helicopter – a familiar scene in the 1960s.



32 ➤ FIRST TV IMAGE OF EARTH FROM ORBIT, 1960 The first weather satellite, TIROS 1, was equipped with television cameras that photographed Earth's cloud cover – the first in a long line of orbiting atmospheric monitors.



33 ▲ APOLLO-SOYUZ, 1975

Alexei Leonov (left) had trained to be the first Soviet man on the moon. Mercury astronaut Deke Slayton had been sidelined for years due to a heart condition. Their "handshake in space" in July 1975 had more to do with U.S.-Soviet détente than with space exploration.



31 ◀ ECHO SATELLITE, 1960
Satellite communications pioneers tried several methods of relaying signals from space, including the inflatable ECHO balloon, which successfully reflected telephone, radio, and TV signals back to Earth.



35 ▶ COMET SHOEMAKER-LEVY, 1994 The largest impact event ever recorded. After scientists predicted that Comet Shoemaker-Levy would break up and collide with Jupiter, all eyes – including the Hubble Space Telescope – turned to watch the impacts, which appeared as dark spots in the Hubble images.



34 ▲ DEEP IMPACT HITS A COMET, 2005 This simple but spectacular experiment – smashing a projectile into a comet nucleus so scientists could study the material that flew out from the icy core – made a public splash by colliding with Comet Tempel 1 on July 4, 2005.



36 ▶ HARRISON SCHMITT, APOLLO 17, 1972 The only scientist to land on the moon, Schmitt had helped train other astronauts to be field geologists. The last Apollo expedition covered the most territory; the astronauts ventured miles from their landing site.



37 ▲ LANDSAT IMAGE, 2002 The LANDSAT Earth observation satellites have returned an unbroken record of Earth photography since the first was launched in 1972. The most recent in the series, Landsat 7, took this image of Cape Cod, Massachusetts, on June 22, 2002.



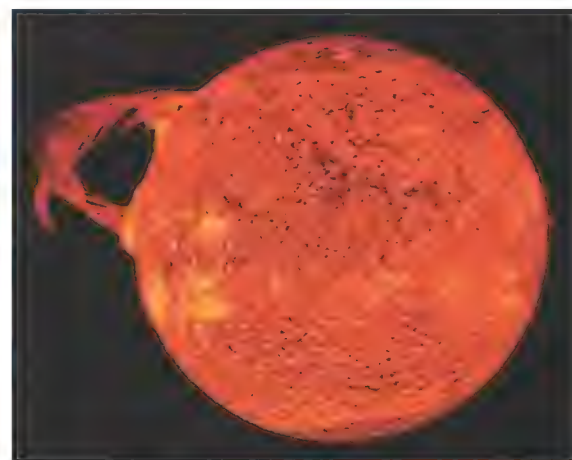
38 ◀ VIKING 2 ON MARS, 1976 The second of two Viking landers touched down on Utopia Plain on September 3, 1976. Due to dust suspended in the thin atmosphere, the Martian sky appeared pink.

#35: HUBBLE SPACE TELESCOPE JUPITER IMAGING TEAM

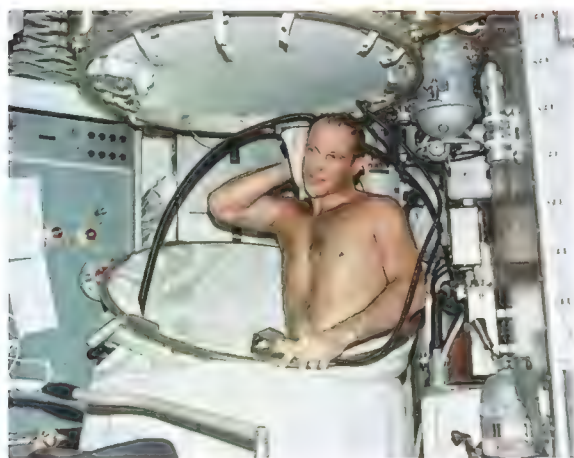
40 > INTERNATIONAL SPACE STATION, 2008 The largest object ever flown in space. First proposed in 1984, the orbiting laboratory is now nearly complete, with European and Japanese modules added earlier this year.



39 v SOLAR FLARE FROM SKYLAB, 1973 NASA satellites stationed between Earth and the sun keep constant watch over the local star. The sun was an object of intense study by astronauts on the Skylab space station of the 1970s, which carried eight solar instruments.



41 < SERVICING HUBBLE, 1993 The Hubble Space Telescope was designed to be serviced regularly by shuttle astronauts, who have repaired and upgraded the orbiting observatory four times. A final service call is scheduled for this fall.



44 ^ SHOWERING ON SKYLAB, 1973 The first U.S. space station had some of the comforts of home, including a galley and a shower (with a vacuum to collect the water). Jack Lousma (pictured) flew on the second (59-day) Skylab mission. The longest stay was 84 days.



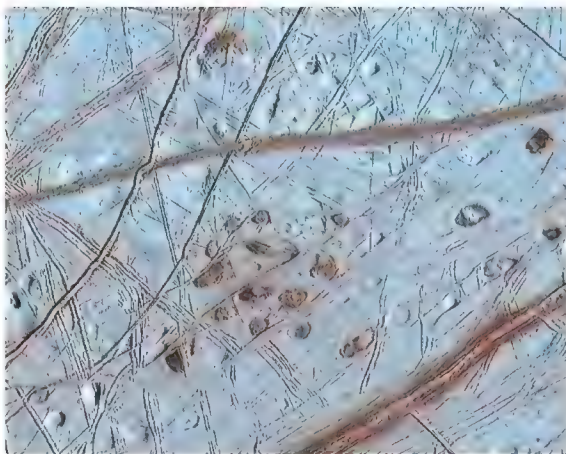
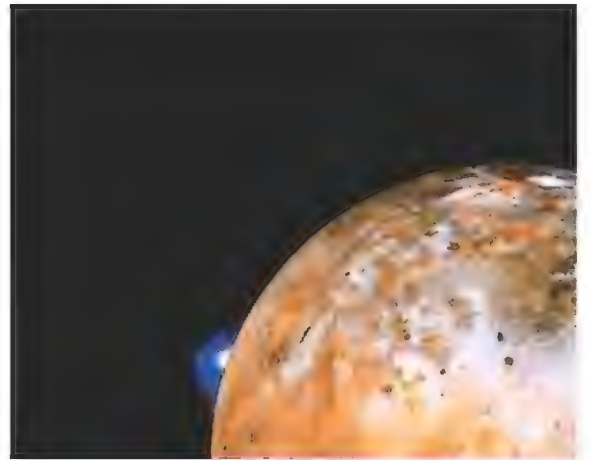


45 ▲ SHUTTLE MID-DECK, 1983 By the space shuttle's eighth mission, astronaut crews had grown larger and more diverse. STS-8 had five people. Guy Bluford (right), the first African-American in space, was also on the record-setting, eight-person crew of STS 61-A two years later.



42 ◀ SATURN FROM CASSINI, 2004 The U.S./European Cassini spacecraft arrived in orbit around Saturn in July 2004, and is now on an extended tour of the ringed planet and its moons. The Huygens probe, dropped onto Titan's surface in January 2005, was the first visitor to that moon.

46 ▶ VOLCANO ON IO, 1979 Among the most important discoveries of the Voyager 1 mission was a plume erupting over Jupiter's moon Io, seen serendipitously in a long-exposure photo – the first volcanic eruption ever detected beyond Earth.



48 ◀ ICE ON EUROPA, 1998 NASA's Galileo mission to Jupiter paid special attention to the moon Europa, where an ocean underlies a cracked shell of water ice. The ocean is a likely place to search for life.



47 ▲ EILEEN COLLINS, 1999 The former test pilot was the first woman commander of a space shuttle mission, on STS-93.

43 ◀ SHUTTLE FERRY FLIGHT, 1998 The space shuttle is ferried home to Florida on a Boeing 747 after (now rare) California landings.

49 ▶ VOYAGER INTERSTELLAR RECORD, 1977 Because the twin Voyager spacecraft would leave the solar system, astronomer Carl Sagan and others created an analog record of sights and sounds from Earth as a message to any civilization that might some day encounter it.



50 ◀ SHUTTLE ENTERPRISE WITH CAST OF STAR TREK, 1976 NASA's prototype space shuttle was to have been named *Constitution*, but fans of the *Star Trek* TV show mounted a write-in campaign that led to it being named *Enterprise*. Here the show's cast (minus William Shatner) poses with the test craft.

Resto

The *Memphis Belle* | Boeing B-17

TWO YEARS AGO, Roger Deere traveled to an eastern Ohio coal town, where he visited a four-room Sears pre-fabricated house whose ceiling bowed down from the weight of all the stuff in the attic. The homeowner had died; a relative poking through the accumulation had run across something he thought might be of interest to Deere. Along with everything else, the attic contained the radio equipment for a B-17 bomber.

Deere did not ask how radio equipment got into the attic. He did not want an explanation; he wanted the equipment.

In time, it will be placed in the *Memphis Belle*, a Boeing B-17F Flying Fortress now being restored at the National Museum of the U.S. Air Force in Dayton, Ohio, where Deere is the chief of the restoration division.

During World War II, the U.S. Army Air Forces required heavy-bomber crews to complete 25 missions before they could go home. In 1943, having flown over France, Belgium, and Germany, the *Memphis Belle* crew became one of the first to reach that goal. After returning to the States in June 1943, the bomber and many of its crew served as the centerpiece of a 31-city War Bonds tour. Academy Award-winning director William Wyler documented the *Belle's* service in a 41-minute color film. The four-engine bomber became the most famous aircraft from the air war in Europe.

The bomber retains its fame today. Those too young to remember it from the war may know its story from the fictionalized 1990 movie *Memphis Belle*, or from the B-17 (used in that movie) that now tours airshows in *Belle* markings.

The real *Belle* owes its present-day survival to a combination of romance and civic pride. In 1946, it was sitting with hundreds of other B-17s in Altus, Oklahoma, ready to be chopped up for scrap. A newspaper reporter learned of its fate and told Memphis mayor Walter Chandler; Chandler bought the B-17, originally costing \$314,000, for the \$350 salvage price as a way to honor the city's namesake ("*Memphis Belle*" is a tribute to resident Margaret Polk, the pilot's girlfriend). But after six decades, local groups concluded they could not raise the funds to complete a needed restoration. In 2004, the Air Force announced plans to relocate the aircraft to its national museum and finish restoring it.

The next year, two convoys trucked the disassembled aircraft to the cluttered World War II-era hangars that now house

the restoration effort. When, five or more years from now, the work is complete, the museum will permanently display the *Belle* to visitors.

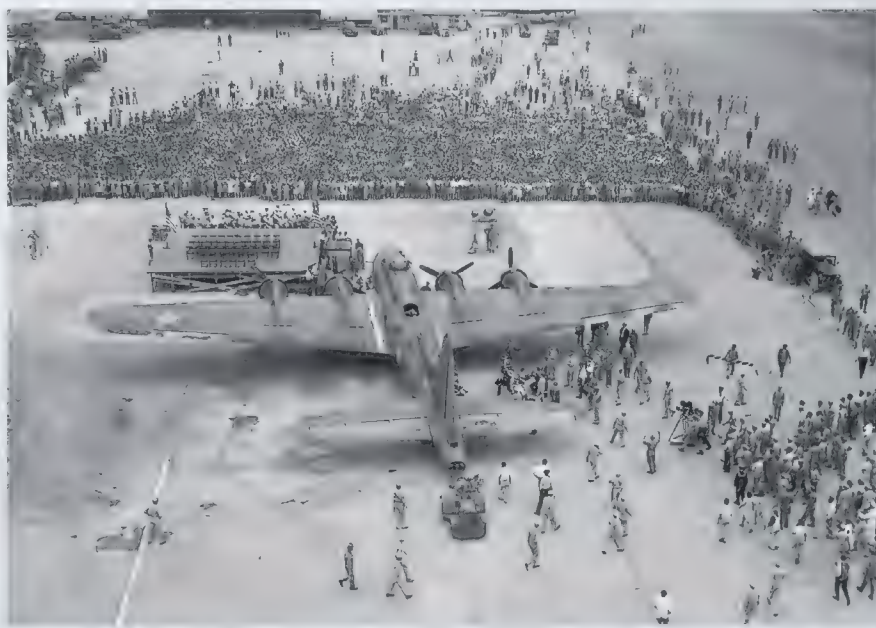
In 25 missions the *Memphis Belle* had its tail splintered, five engines shot out, and its body pocked with hundreds of holes from German flak. The worst damage, however, came in peacetime: Vandals made off with almost everything not fastened down; "Sometimes they pried things off the walls," says Deere. The *Belle* is now missing most of the interior: the pilot, copilot, and navigator seats, the control yokes, and much more.

Finding replacements is difficult. While the United States built 13,700 B-17s, fewer than 100 remain. "There are structural parts we're never going to find unless somebody runs across a B-17 sitting out in a field somewhere," Deere says.

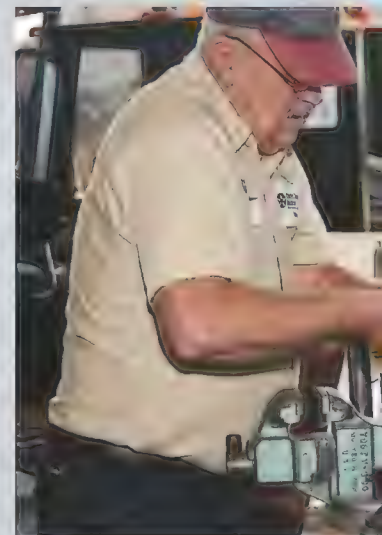
For some pieces, replacements are being fabricated. Molds have been made for the plexiglass in the top turret, and for an aft fuselage ring frame. The engines that came with the *Memphis Belle's* other parts were not original to a B-17,

so they'll be replaced with rebuilds assembled from the museum's substantial accumulation of aircraft parts.

The original cloth-



After 25 missions, the crew (left) and the *Belle* went on a War Bonds tour, stopping at Patterson Field in Ohio (above). Recalling the tour decades later, Commander Robert Morgan wrote: "In today's lingo, our uniforms were dazzling 'chick magnets.' "



restoration

coated wire is no longer made in the United States, so the restorers are buying it new in Great Britain. Though the wires will be out of sight, the restorers are intent on making the aircraft as authentic as possible.

As for the body, all the paint is being stripped. Paint, Deere says, “hides a lot of corrosion. We want to get it stripped down so we can undertake the structural repairs first.” The work is slow, in part because no chemical strippers are being used on the interior. “Manufacturers claim their chemicals are not corrosive,” says Deere. “Maybe it’s not corrosive now, but what about in five or ten years?” Working with the restorers, private-sector chemists modified an existing product into a sand-like dry stripper that addressed Deere’s concerns. The entire aircraft should be stripped by year’s end.

Besides revealing underlying corrosion, stripping brought to daylight more than 1,000 names inscribed in the aircraft’s tail and fuselage by the public during the bond drive. The names have been photographed; they will disappear again when the aircraft is repainted.

The aircraft arrived with several large patches on its



USAF

tail. They were quick-and-easy fixes made with flat sheet metal; the original tail, however, had a compound contour. Those are much harder to fabricate.

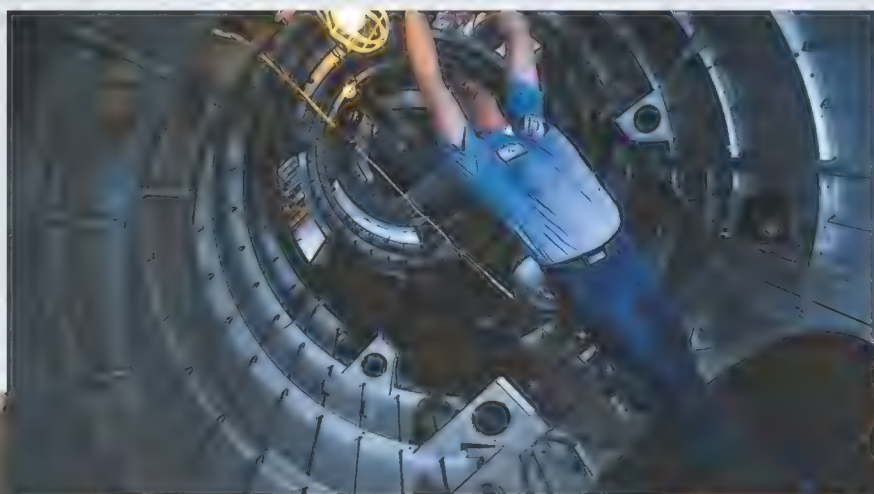
Staff efforts are supported by volunteers. The head restorer of the tail gun is John Vance, whose father was a B-17 tail gunner. Volunteers Chuck Flaum and Steve Markman built 10 replicas of the

The *Belle* arrived at the Air Force museum in 2005 (above). Now, every Friday visitors can see it undergoing restoration (advance tour registration is required).

wooden carriers that held the oxygen bottles crew members carried while moving inside the unpressurized craft. They found the original blueprints on microfiche at the National Archives.

Some parts just can’t be replicated. Deere would particularly like the instrument panel with the manufacturer’s data plate, which is specific to the *Memphis Belle*. “Somebody’s got it,” he says. “We’d like it back—no questions asked.”

MARK BERNSTEIN



MASTER SGT. CECILIO RICARDO/USAF



USAF

In the U.S. Air Force museum in Dayton, Ohio, volunteer John Vance works on one of the *Belle*’s landing gear struts (left), staff restorer Tom Bachman tags areas of the fuselage (above), and the bomber’s Wright R-1820-97 turbo-supercharged radial engines await attention.



USAF

Accidental Classic

From the designers who brought you the P-51 Mustang, an airplane with a complicated



IN THE SUMMER OF 1951, a herd of donkeys charged across the tarmac of Mexico's Acapulco airport, tearing into a row of parked, private airplanes. Most of the aircraft, made of wood and fabric, were severely damaged. When one of the donkeys crashed into the left wing of an all-metal Ryan Navion, the collision was so fast and so violent that a main landing gear was lifted 10 inches off the ground. But though the donkey was badly injured, the Navion's

past...and a controversial present. *by Mark Huber*

wing suffered only a minor dent.

When Salvador Mariscal, Navion's Latin America distributor, recounted the tale to Ryan's Bill Wagner—perhaps the most prolific aviation PR man of the 1940s and 1950s—Wagner quickly issued a press release headlined “Navion Demonstrated As ‘Jackass Proof.’”

Donkey collisions are perhaps the most obscure way the Navion has proved its durability over the past six decades. Between 1946 and 1951, Ryan Aeronautical and North American Aviation built 2,349 of the 2,469 Navions produced. (Several other companies, most notably the Tubular Service and Engineering Company—TUSCO—built variants that account for the other 120.) Today, an estimated 500 to 600 still fly, kept airworthy by members of the American Navion Society and other groups of enthusiasts who appreciate the curious history of this tough little airplane as much as its handling characteristics. “The Navion is an amazing aircraft,” says David Peters, operations manager at Classic Airworks, an aircraft restoration company. “It’s just a really stout beast. That, combined with its warbird lineage, initially attracted me to the aircraft.... The same care and thought that went into the design



LEFT: ©GEORGE A. KOUNIS; RIGHT: RYAN AERONAUTICAL ARCHIVES/SIERRA HOTEL AERO



The roomy Navion remains a favorite for a leisurely hop in uncrowded skies (left, an L-17 flies over Vermont's Basin Harbor Airport; above, a satisfied customer, c. 1955).

of the war machines went into the Navion.”

When Ryan failed to sell the Navion as a military trainer, the company shuttered the program and sold the type certificate to TUSCO, which restarted production in Galveston, Texas, in 1958. Three years later, Hurricane Carla slammed into the Gulf Coast. The worst storm to hit Texas in 40 years, it killed 43 people and leveled Galveston. The TUSCO plant was crushed, and the company never recovered.

Over the years, the Navion’s type certificate was held by various dreamers who hoped to restart production but didn’t have the money. In 1995, John Piper, grandson of Piper Aircraft founder William Piper, attempted a revival. Seven years later the effort ended in bankruptcy. When the type certificate came up for auction in 2002, Northwest Airlines crew chief Chris Gardner acquired the rights as well as truckloads of parts, tooling, and documents. Gardner had experience with the airplane; his father, Jon, had owned Navions, and had developed an external baggage door modification for the type. “I was really intrigued with the airplane because of the way it was put together,” says Gardner. “It was built a lot like a Mustang, and you could tell the



same people designed it. When the type certificate became available, I knew that would make things a lot easier in terms of upgrading the airplane, because the airplane itself is a wonderful platform.

“My goal was to support the existing fleet, but my long-term goal is to one day build the airplanes again. That’s still a long-term dream.”

In 2001, the Federal Aviation Administration granted to Chris Gardner “Parts Manufacturing Authority,” a license al-

“It’s the Hummer of airplanes,” says type certificate holder Chris Gardner. “You can land the Navion anywhere. People use them for hunting and camping.”

lowing someone other than the original manufacturer to produce aircraft parts. Gardner soon discovered that certain aspects of the Navion’s design didn’t meet current safety standards, and one of the replacements he devised, an \$800 fuel selector valve, became mandated by an FAA



LEFT: CAROLINE SHEEN; TOP: MAX HAYNES / MAXAIR2AIR.COM

Airworthiness Directive (AD), issued on April 16, 2008. The FAA estimates that it will cost each Navion owner \$1,800 to inspect the aircraft's fuel system, remove the old valve, and replace it; owners have one year to comply.

The Airworthiness Directive has earned Gardner the enmity of the American Navion Society and many Navion owners, who view him as a profiteer. Sixteen went so far as to formally object to the FAA about the directive on the grounds that Gardner "is using the AD process to make money."

"They hate me," Gardner acknowledges.

THE NAVION HASN'T ALWAYS stirred such strong feelings, much to the disappointment of its manufacturers. As World War II came to a close and warbird production began shutting down, North American Aviation needed a project to sustain its skilled workforce, which had been building P-51 Mustangs, during the 18-month gap before it could begin manufacturing the F-86 Sabre. The Navion program was cobbled together in a mere 30 days when the company decided to market a liaison aircraft to the U.S. military.

Because of the tight 18-month window, the same talent trust that designed the P-51 and the T-28 would design the Navion. The aircraft shares the T-28's seven-degree, 30-minutes of wing dihedral, and it has many of the Mustang's pleasant handling characteristics and robust design features; its nickname is "the poor man's Mustang."

North American churned out 1,100 Navions in nine months. Those destined for the military were labeled L-17As, while those sold to civilians were called A models. Each airplane cost \$9,000 to build, and sold for \$6,100. With the coming F-86 contract and its profit potential of tens of millions, North American was unconcerned with losses generated by what amounted to a rounding error. There was also a chance that if the Navion were selected as the military's new primary trainer, the program would

Navion fans Steve Whittenberger, Bud Brown, and Dave Carpenter (left to right) stroll past their airplanes at the 2008 Oshkosh, Wisconsin fly-in. Do those tails remind you of P-51s?



Warbird Lineage

DESIGNATED AS THE L-17 for the United States Army Air Forces, the Navion flew from aircraft carriers during the Korean War. With its canopy removed, it hauled oversized truck tires in Alaska. And because it could fly with its canopy off, the airplane was among the

camera platforms used by legendary Hollywood aerial cinematographer and stunt pilot Paul Mantz.

In addition to transporting Korean War brass (including General Douglas MacArthur and Major General Matthew Ridgeway), Navions served notable celebrity-pilots of the 1950s: Radio icon Arthur Godfrey, actors Mickey Rooney and Robert Young, and comedian Red Buttons all owned Navions. Manufacturer Ryan Aeronautical even featured Godfrey in a promotional film entitled *Yours to Fly*. In it, Godfrey can be seen piloting the airplane to altitude, leveling off, and then lighting up one of his trademark Chesterfield cigarettes.

After the Korean War, the L-17 continued to see military service until the late 1950s, when virtually all were transferred to the Civil Air Patrol. Less than a third of the L-17 fleet survives today, according to Bill Lattimer, who runs a Web site dedicated to the type (www.warbird.org/L-17).

eventually make money.

The Army Air Forces bought 83, but shortly after F-86 production began, North American sold the Navion line to Ryan Aeronautical in San Diego, which continued production from 1947 to 1953.

In 1950, Ryan introduced the B model, the Super Navion, which featured a 260-horsepower engine that could increase cruising speed to 170 mph. The bigger engine required a longer, reshaped nose cowl and a larger propeller; with the more powerful engine, the airplane could take off in as little as 400 feet. But Ryan did not adopt North American's "loss leader" pricing, and sold the B for \$14,000.

The Pentagon ordered an additional 163 L-17Bs from Ryan. These aircraft were primarily relegated to liaison duties, flying high-priority personnel and small cargo; some, however, were used in Korea for forward air control missions, providing coordination of air strikes by F-80s, the first U.S. operational jet fighter.

A limited contract for liaison aircraft was not the military grand prize Ryan envisioned. The company was hoping for the U.S. Air Force's lucrative flight trainer

contract. But in 1953, Ryan's entry, a modified Navion B designated the Model 72, lost out to the faster T-34A Mentor, Beech's militarized version of its Bonanza. The following year the Navy also selected the Mentor. The Bonanza proved more popular than the Navion with civilian customers as well. Pilots, mostly male at the time, who wanted their wives along on joy rides, bought the Bonanza, an easier airplane to climb into. "In the 1950s, if you were wearing a peg skirt, there was just no ladylike way to get into a Navion," explains Navion owner Margy Natalie, docent program manager at the National Air and Space Museum's Steven F. Udvar-Hazy Center.

But the orphan airplane that no manufacturer could keep in production remains popular with its owners. "You can find a Navion for \$40,000," says Peters. "You can't even find a worn-out Cessna for that." Today, a non-flying project airplane can be had for under \$10,000, a flyable one with a tired engine or beat-up paint for \$35,000, and a Navion that has been restored to near-mint condition for \$100,000 to \$170,000, depending on engine size and other



Ron Judy (left, with American Navion Society president Gary Rankin) spent six years restoring his airplane, much admired at Oshkosh this year.

modifications. In an age of \$400,000 Cirruses, \$600,000 Cessna 400s (formerly Columbia), and \$700,000 Beechcraft Bonanzas, the Navion looks like a bargain.

In addition to the price, enthusiasts point to the Navion's military lines, sliding canopies, high stance, beefy landing gear, good load capacity, and overall solid construction as reasons for the aircraft's enduring appeal.

"It's one of the best airplanes ever built, one of the most stable, and we think that it would do very well in an international

environment," says Gardner. "Third World-country operators would find this airplane very, very useful because of its payload, its short landing capability, and its stableness."

"It's very easy to see out of," says American Navion Society president Gary Rankin, who has owned four since 1986. "The handling is very docile, and it lands slow. It has big tires and high gear, and can land on rough runways."

In May 1960, Bob Swanzy, a retired road construction engineer from Greenwood, Mississippi, was driving through Memphis when he saw a 1947 Navion for sale. He bought it for \$4,500, and some 5,000 hours and four engines later, he is still flying it. "It just suits me," Swanzy says. "You can load it down with baggage. You just crank [the engine] up. If the tail comes off the ground, you go."

Dick McSpadden, who flies out of Canon, Georgia, and is the former president of the 156-member Southern Navion Air Group, agrees. "Whatever you can put into it, it's going to fly. At 75 miles per hour, it is going to come off the ground."

Ron Judy, who is the American Navion Society's chief technical advisor, says that in cross-country trips, the Navion really shines in "dirty," or turbulent, air: "When I'm flying through moderate turbulence, I barely feel it. Meanwhile, a guy in a Cessna 150 in the same air is getting beat to death." Judy, a Gate, Oklahoma rancher who spent six years restor-

ing his Navion, says the structure and area of the airfoil contribute to the stability. "It's a monocoque wing with no spars, just ribs, stringers, and subspars to hold the [retractable] landing gear. The wing skins and stringers provide the structural strength. The wing is evenly loaded across a large area. The wing design delivers a smooth ride and high lift and makes the airplane very controllable at low speeds."

The Navion's wing consists of two different airfoils that join approximately 50 inches from the wing root. With landing gear and flaps extended, a Navion stalls at just 48 mph, about the same stall speed as the much smaller—and much lighter—Cessna 152.

Ruggedness and stability aside, most owners were initially attracted by the aircraft's distinctive good looks. "It's coming from an era where design for aesthetic purposes was as important as anything else," says David Peters (who provided artwork for this article).

IN ISSUING THE AIRWORTHINESS Directive, the FAA cited nine Navion accidents generally associated with the fuel system, three of which were directly linked to the fuel selector valve. The agency also speculated that many of the existing valves might be reaching the end of their serviceable lives.

Gardner claims that since his company bought the Navion type certificate, 18 fuel-system-related accidents



"The Poor Man's Mustang"

DESIGNED BY THE GENIUSES at North American Aviation, the company responsible for the T-6 Texan trainer and the P-51, the Navion shares many of the Mustang's robust design

features – although no common parts – earning it the nickname "the poor man's Mustang."

Same profile? You decide.



DAVID PETERS

have occurred, and that he issued a service bulletin recommending action to Navion owners as early as 2004. Most of the accidents occurred on takeoff at high engine power settings, when defective or improperly repaired valves allowed the vacuum fuel system to ingest air, causing the engines to stop.

Navion owners who objected to the AD succeeded in getting the FAA to slightly modify it. "The proposed AD, with the references it used for doing the inspection, left much to be desired, safety-wise," said Judy. "The American Navion Society wrote a Service Bulletin and submitted it to the FAA, and the FAA included portions of it in the final version as a means of conducting the inspection." Judy, who had a valve fail 17 years ago, now believes the AD is acceptable, but prefers the Alternate Means of Compliance (AMOC).

According to Gardner, he and the Navion Society are competing parts suppliers. He says that the paperwork-intensive and time-consuming AMOC—a detailed inspection that does not preclude the need for valve replacement and is available only to society members—is actually more expensive than

So popular is the Navion that airplane lovers consider a completed restoration, like David Peters' (above), the proverbial pot of gold at the end of the rainbow.

simply replacing the valve in the first place. Judy points out that the stringent inspection of the fuel valve required under the AD virtually guarantees that the valve will not pass.

Even with the AD and accompanying controversy, McSpadden maintains that Navions are relatively inexpensive to maintain: "Our parts are less expensive than for almost any other airplane." And whether following the AD or pursuing the AMOC, Navion owners are doing whatever it takes so that they can continue to fly their favorite aircraft.

Navion owners are increasingly a graying crowd, and the future support of the airplane will rest with younger enthusiasts, who, like Chris Gardner, were introduced to the craft by their parents. McSpadden notes with pride that his son, Air Force Lieutenant Colonel Richard McSpadden, learned to fly in his L-17 military Navion and in 2002 and 2003 served as team leader for the U.S. Air Force Thunderbirds Flight

Demonstration Team. "He still flies the Navion," McSpadden says. Rankin acknowledges, "About half of our younger members are second-generation Navion owners."

When the American Navion Society gathered for its annual convention in Dayton, Ohio, this past summer, there were the usual speed events, and the presentation of the Flagship Award for best restoration. Members showed off items from their personal collections of Navion memorabilia. Ron Judy has a copy of a Ryan brochure from the early 1950s that shows a crated pig being loaded into the back of a Navion at Hyland Farms in Peoria, Illinois. As he tells the story, Judy glances over at his meticulous Navion, with its shiny red and white paint, polished aluminum spinner, and dove-gray leather interior. This is the airplane he took six years to rebuild, completely disassembling it, stripping out all the wiring, replacing the fuel and hydraulics systems, rebuilding the landing gear, and installing all new instruments and avionics.

"I guess it was a valuable pig," he says. "Breeding stock maybe. But no pigs are getting in my airplane!" —



Fly Us to the Moon

THE NEXT LUNAR EXPLORERS WILL SOON REPORT TO HOUSTON. ARE SOME ALREADY THERE?

BY MICHAEL CASSUTT

ON A WARM FALL DAY in September 1962, a young U.S. Air Force captain named Tom Stafford sat on the stage of a University of Houston auditorium with eight other men. They had just been named the second group of NASA astronauts. As reporters peppered them with questions about hometowns and families, Stafford looked to his right and left and thought, *One of us is going to be the first to walk on the moon.*

He was right: One of the nine was Neil Armstrong. Like Stafford, Armstrong was a member of the pioneering first generation of NASA astronauts—73 in all, selected between May 1959 and August 1969. Most were experimental test pilots. The rest were either military pilots or professional scientists who had to qualify by flying jet aircraft. They could not be taller than five foot eleven, and their eyesight had to be 20/20 without correction. The first groups had to endure a week of hellish medical tests. All were white males.

In 1978, the second generation emerged: the first group of astronauts selected to fly on the space shuttle. For them, the medical requirements were eased considerably, because the launch and entry stresses of the shuttle were more benign. The new astronauts could be as tall as six foot four and, for some, glasses or contact lenses were allowed. Fifteen of the “Thirty-Five New Guys” were test pilots, but 20 were “mission specialists”—engineers and scientists, some of whom had no piloting skills at all. None of the mission specialists

had to qualify as a pilot; they only had to ride in the back of the T-38 Talon jet trainers to show that they could work effectively as members of flight crews. Six of the TFNGs were women, four were minorities. Over the next 26 years, through 2004, more groups were trained, bringing the number of shuttle astronauts to 238.

The astronauts to be picked in 2009—NASA’s 20th group—will be the first of a third generation, and theirs will be a particularly daunting mission: Return America to the moon on an entirely new spacecraft. “We will no longer be flying on the shuttle,” says Steve Lindsey, the four-time space flier who since October 2006 has headed the astronaut office at NASA’s Johnson Space Center in Houston. “By 2011, when the new candidates complete their initial training, we won’t even have the [shuttle] simulators.” The 2009s will also face more restrictive physical admission criteria than the shuttle generation. Because they are being selected initially for International Space Station missions, the new candidates will have to fit in a Russian Soyuz spacecraft, which has a height restriction of six foot three. “It’s not just a matter of height, but all kinds of anthropometrics: leg length, sitting height,” says Lindsey. So, with NASA again planning long trips in small capsules, prospective astronauts will have to be just a bit shorter than their shuttle brethren.

As usual, NASA won’t have any problem filling the astronaut ranks. In the latest call for applications, 3,535 people are vying to gain a seat in the astronaut class of 2009. A panel headed by Duane Ross, manager of astronaut selection for the past 42 years, will conduct several reviews of the pool, first eliminating those who don’t meet the qualifications, then winnowing them further, looking for the right balance of achievement and versatility. About 120 applicants will be

One of these shuttle astronauts could get the call for a moon mission. Top to bottom, left to right: mission specialists Tracy Caldwell, Mike Fincke, pilots Tony Antonelli, Jim Dutton, Terry Virts, mission specialists Robert Behnken, Karen Nyberg, pilots Jim “Vegas” Kelly, Mark Kelly, Pam Melroy, Randy Bresnik, and mission specialist Megan McArthur.

ALL PHOTOGRAPHS: NASA

identified, and 20 at a time will be invited to Houston for a week of medical tests and interviews beginning this month. From that group, about 40 will be called back to NASA next February and March for more extensive screening. In late April, Lindsey or flight crew operations director Brent Jett will call those selected from that round, inviting them to join the astronaut team.

"We're looking at a group from 10 to 15," says Ross. "The final number will depend on how big the astronaut office is at the time we make the decision." There are now 90 active-status astronauts, but by the time the 2009s are eligible for flight assignment, the number is expected to shrink to 60. Once the last shuttle crews are named, next May or June, attrition may increase, since those remaining have to compete for slots on the three-seat Soyuz flying to the space station.

Since NASA began selecting women as astronauts 30 years ago, it has never chosen fewer than two in each astronaut group. Based on past experience, expect a third of the 2009s

to be female. There will be a similar number of minority candidates. And while eight to 12 of the new astronauts will be scientists, engineers, or current NASA employees (with overlap among the categories), three or four will come from the traditional test pilot community. According to Lindsey, a former test pilot, "They are pilots, they've been in operational squadrons, some have been in combat. They have been through test pilot school and

have worked on flight test programs. They come to the astronaut office with the ideal background."

But NASA wants more. "It's vital for us to have a variety of skill sets and points of view in the astronaut office," says Lindsey. "When you put

test pilots together with scientists, both sides learn. Pilots need to learn science, scientists need to learn operational skills."

The 2009s will also differ from the shuttle-era groups in that they'll drop the distinctions between flight duties. "We've eliminated the caste system," says veteran shuttle astronaut Marsha Ivins. Instead of having titles like "pilot" or "mission

specialist," the new astronauts will all be simply "operators." There won't be any teachers-in-space, either; NASA dropped the "educator mission specialist" classification last year. "Educators will be welcome," says Ross, "but they will be competing, the same as everyone."

Beyond Soyuz flights to the space station, the new astronauts can look forward to the Constellation program and the Orion spacecraft. "Constellation is the mission to get us back to the moon," says Mark Geyer, Orion project manager. "Orion is the element that allows us to continue operating in low Earth orbit, flying crews and supplies to the International Space Station beginning in 2015, then allowing us to go onto the moon."

Constellation's other components include the Ares I and Ares V rockets, the Earth Departure Stage, and the Altair lunar lander. Along with Ares I, which is based on the shuttle's solid rocket booster, the Orion crew module is the most developed of the elements (see "Orion's Brain," Sept. 2007). Orion is shaped like the Apollo command module but is 50 percent larger and can carry six people to low Earth orbit, or four to lunar orbit.

"No one at NASA has designed a new manned vehicle in over 30 years," says Ivins, who heads the astronaut office's Constellation branch. "A whole generation has never had that experience." But the new generation of astronauts will be part of the design process, just as the Mercury astronauts were. Randy Bresnik, a Marine test pilot in the 2004 astronaut group, currently is helping shape Orion's design. "The spacecraft should take the workload off the crew for mundane tasks," he says. "In the shuttle, you spend a lot of time training to go to the right page in a thick flight data file. Orion operators should only do the things a computer can't do." Still, Bresnik says, there remains a role for "pink squishy bodies" in space. "We know where to look when there's a problem."

THE 2009s WILL BE CERTIFIED as full-fledged astronauts in 2011. By then, they will already be working on technical assignments—as capsule communicators, or capcoms, or

Marsha Ivins, Class of 1984: Five-time shuttle flier heads the Constellation program's exploration branch, but is probably too late in her career for a moon landing.

Tony Antonelli, Class of 2000. This Navy pilot awaits his first shuttle flight. He could still be on flight status in 2019.





as crew support astronauts for station missions, payloads, hardware, spacewalks, and robotics. And they will be obsessing over this question: Will I get to go to the moon?

One problem confronting them will be a lack of flight opportunities. Through the shuttle era, new astronauts could expect to make three to five flights in an active career that averaged a dozen years. "In some years, we had 50 different astronauts in space," says former shuttle astronaut Jeff Hoffman. "With Orion and ISS, that number will be more like a dozen. The new candidates will be looking at one or two flights at most in their entire career." It's a model that recalls the Apollo era.

But this generation will differ from its predecessors in one key area. According to Andrew Chaikin, author of *A Man on the Moon*, the Apollo astronauts did little reflecting on or sharing of their experiences; they were too concerned with timelines, and they often were simply uninterested in doing so by temperament. After all, they were pilots, not poets or geologists. "You had to do the 'exploring' in order to get to do the flying," Apollo 12 commander Pete Conrad told Chaikin.

From the first Mercury missions onward, NASA was open about its activities, but was often clueless about the benefits of better communication with the public. Stafford wanted to carry a color-TV camera on Apollo 10 (earlier Apollo missions had used black-and-white cameras), but he found NASA tremendously resistant. Even shuttle astronauts were not universally eager to communicate the wonders of exploration, or to explore at all. Former astronaut Tom Jones recalls that

Mark Kelly (above), and his twin, Scott, Class of 1996:

Mark has flown in space three times, Scott twice. Navy pilots with space shuttle command experience that could be an important factor in picking crew for a lunar mission.



when he would give informal seminars on new developments in astronomy, or futuristic missions like manned asteroid flybys or comet landings, a small but notable element within the pilot ranks would react with bafflement or indifference. "Who cares about a blasted hunk of rock in space?" one asked.

The 2009s, on the other hand, will be cut out for show-and-tell. Says Chaikin, "If the Baby Boomers are the 'Me Generation,' those who are in their 20s and 30s now are the 'Look-at-Me Generation.' They are more comfortable being on stage and sharing their experiences with blogs and YouTube. The Orion-Altair astronauts will face the same pressures of timeline and checklists the Apollo men did, but their missions will be longer. They will have time to reflect, then relate their experiences to those of us on Earth. They understand that they represent those of us who can't go." Some of the recent space station crews understand that; several station astronauts have written blogs while in orbit.

No matter how media-savvy the new astronauts are, they'll find that the Constellation program presents challenges and opportunities that dwarf Apollo in complexity and ambition. For one thing, the Altair lander is only one of three basic ve-

hicles on the drawing board; there's also an outpost and a pressurized logistics module. Based on the Altair design, the outpost will provide living quarters for four astronauts during lunar missions lasting 14, 28, or even 180 days.

The logistics module will provide needed supplies and other equipment, such as a pressurized lunar rover or a crane to transfer cargo. The design is immensely complicated by the twin goals of sustainability and operability. "All equipment has to be able to work in three modes: with an astronaut in control, remotely from mission control, and independently," says Chris Culbert of the lunar surface systems office. Mobility is key. "It's not just moving from point A to point B, it's being able to do something once you get there," he says.

THE NASA THAT THE NEW CANDIDATES will be joining is a more jittery organization than the one that greeted earlier classes. In the wake of the 2007 scandal in which shuttle astronaut Lisa Nowak was charged with assaulting a rival for the affections of another astronaut, the 2009s will face greater psychological testing than their predecessors, though, Duane Ross points out, "We already spend more time in the interview week on that subject than on any other."

Patricia Santy, a former NASA medical officer, says that the problem isn't the initial interview. It's lack of follow-up. "The assumption is that once you've been selected as an astronaut, you're good," she says. "Yet what happens after selection is what changes astronauts most dramatically. They are placed in a narcissistic-enabling environment, treated like gods. You have situations where experienced, senior people in medicine are overruled by people just out of med school just because they happen to be astronauts."

Hoffman doubts that follow-ups are the answer. "People who are clever enough to get past the first screening will be clever enough to pass the follow-ups too," he says.

Nevertheless, astronaut managers continue to gather data on the traits that are best suited for this dangerous yet attractive profession. Behavioral scientist Jack Stuster, author of *Bold Endeavours*, a 1996 study of historic exploratory missions and a frequent lecturer at the astronaut office, has a continuing study of space station crew members that builds on earlier work with Navy personnel and civilians on Antarctic research teams. "When it came to ranking the traits desirable for fellow crew members, Navy personnel ranked emotional control first, followed by compatibility," says Stuster. "Civilians had them reversed: Compatibility was most important, followed by emotional control. But both groups put technical proficiency third."

Compatibility is important at Johnson. Says Lindsey, "The primary purpose of the astronaut interview is to ask yourself, 'Could I spend 14 days locked up in a Winnebago with this person?'" NASA tackles the compatibility issue by putting astronauts under stress throughout their careers. "One of the most useful programs we have is sending astronauts to the National Outdoor Leadership School," says Lindsey. "You spend around 12 days in places like the Wind River Range or Canyonlands in Utah, learning about self-care and buddy-care, interpersonal stuff, working as a team."

A second phase uses the NASA Extreme Environments Mis-

sion Operations (NEEMO) program, in which teams of astronauts and engineers work in the underwater Aquarius lab off Key Largo, Florida. "These are great analogs for shuttle missions," Lindsey says. "Eleven, 12, 14 days where you do scuba dives, which are just like EVA [extra-vehicular activity—spacewalks]. NEEMO missions will also be relevant to lunar missions. In fact, we're doing research now in suits for lunar EVAs, learning about suit weight and center of gravity."

If compatibility is what makes a successful mission in an extreme environment, like the space station or Orion, should NASA be choosing people who have proven themselves in similar situations: submariners, deep-sea divers, oil rig workers? Hoffman, who has a doctorate in astronomy and was one of the spacewalkers who in 1993 repaired the Hubble Space Telescope, doesn't think so. Referring to the 1998 movie *Armageddon*, in which oil riggers are sent into space to divert an Earth-threatening asteroid, Hoffman says, "With all due respect to Bruce Willis, it's a lot easier to train a Ph.D. to do EVA than it is to train a construction worker to handle the technical requirements of spaceflight."

What about the possibility that the next lunar explorers won't be NASA astronauts? Could oil-rich Russia ignite a second moon race? Officials in Roskosmos, the Russian air and space agency, have spoken about the possibility, but no program has been announced or funded. NASA Administrator Michael Griffin has said China might beat America back to the moon—technically possible, given the development of its Long March 5 booster and a lunar lander. But the Chinese government has made no

Karen Nyberg, Class of 2000. Mechanical engineer worked on thermal control concepts for a moon lander and flew on *Discovery* in May to the space station.



pronouncements about manned missions beyond Earth orbit.

One thing the next moonwalker won't be is a commercial astronaut, like Mike Melvill or Brian Binnie, the pilots of *SpaceShipOne*, which won the Ansari X-Prize for the first private manned spaceflights. There may well be dozens, possibly hundreds, of people who earn astronaut "wings" as passengers on Virgin Galactic's suborbital flights to an altitude above 62 miles. And by 2019, we may have seen commercial astronauts from Bigelow Space, SpaceX, or Orbital Sciences in Earth orbit. But according to NASA's Ross, they won't be flying to the moon by then. "It will be business as usual," he says.

WHILE THE CLASS OF 2009 will likely provide at least one member of the next lunar team, others may well be working in Houston already. Experience would be important to a lunar expedition, and NASA has tended to give command of a new vehicle to veterans. For example, long-time astronaut John Young was commander of the first space shuttle flight, in 1981, at age 50. Young had already flown twice on Gemini and twice on Apollo and had walked on the moon. For his *Columbia* crewmate, Bob Crippen, who was named an astronaut in 1969, the shuttle launch was his first trip to orbit.

Current astronauts Jim "Vegas" Kelly, a two-time shuttle



Mike Fincke: Class of 1996. Young, eager, and has a declared interest in landing on the moon. Plus, he played a cameo role on a *Star Trek* episode. Spent six months on the space station in 2004 and will return this fall as the station's Expedition 18 mission commander.

pilot, and three-time flier Pam Melroy, who is working on Orion development, have both expressed a desire to fly Orion missions. Pilots Scott Kelly and his twin brother Mark are also mentioned as committed to long-term careers at NASA. Astronaut Peggy Whitson, veteran of two space station expeditions—one as mission commander—is another astronaut believed to have a long-standing interest in exploration. By the time of the first lunar flights, however, all of these veterans would be in their mid- to late 50s. Not an absolute disqualifier, but certainly a factor. Andy Thomas, for instance, describes himself as "too young for Apollo, too old for Altair."

It's more likely that the Orion-Altair crew of 2019 will come from those astronauts around age 40 today. They number only a dozen of the active members of the astronaut office, including pilots like Bresnik and Tony Antonelli, Terry Virts, and Jim Dutton, and mission specialists like Tracy Caldwell, Megan McArthur, Karen Nyberg, Robert Behnken, and Mike Fincke. All have either helped in the Orion design or will be asked to, though an astronaut's technical assignment now is a poor indicator of a future flight assignment, especially when such decisions are years away.

Fincke, who attended a summer exchange cosmonautics program at the Moscow Aviation Institute before becoming an astronaut and an Air Force flight test engineer, is constantly mentioned in conversations with NASA insiders and informed observers as a likely member of the next lunar crew.

Of course, this is speculation. The lunar astronauts won't be named for another decade—and that's if NASA's moon plans stay on track. What's certain is that sometime next May, a dozen men and women will be sitting on a dais in a NASA press conference in Houston or in Washington, D.C. Some may well have their own Stafford moment, looking right, then left, and thinking, *One of us is going to be the next to walk on the moon.* And then they'll probably blog about it. —



The Ouija

BY MARK WOLVERTON | ILLUSTRATION BY JOHN MACNEILL

GUYS GATHERED AROUND A TABLE, PLAYING WITH TOY AIRPLANES: IT'S A SCENE YOU'D EXPECT TO FIND IN THE BACK OF A COMIC BOOK STORE FREQUENT-ED BY GEEKY TEENAGERS. BUT IT'S HAPPENING 24 HOURS A DAY ON U.S. AIRCRAFT CARRIERS AROUND THE GLOBE. THE GUYS STANDING AROUND THE

table are U.S. Navy officers, and the little models they're playing with represent multi-million-dollar aircraft. They're manning the "ouija board," a system they use to track every move of every airplane on a carrier.

"The ouija board is one of the most critical tools we have in coordinating flight operations," says Lieutenant Commander Ray Spradlin, aircraft handler aboard the USS *Enterprise*. It's a replica of the carrier's flight deck and hangar deck, on a scale of 1/16 inch to one foot. The board is about six feet long and two and a half feet wide, about the size of a large coffee table, with the flight deck on top and the hangar bay underneath, like a second shelf. Scattered over both surfaces are small templates representing aircraft, made to the same scale, "so in theory, anything that'll fit on the ouija board in flight deck control will fit out on the flight deck or in the hangar bay," Spradlin says.

A carrier flight deck is a dangerous place, with huge machines in constant motion, screaming jet exhausts, spinning rotors, flexing steel cables, powerful catapults, and men and women working amid it all. To avoid disaster, it's crucial to know what's happening where and when. The ouija board provides a real-time snapshot of the whereabouts of the approximately 70 aircraft on board.

To represent crucial data on each airplane, such as its armament, maintenance needs, and mission status, "we use low-tech gadgets like thumbtacks,

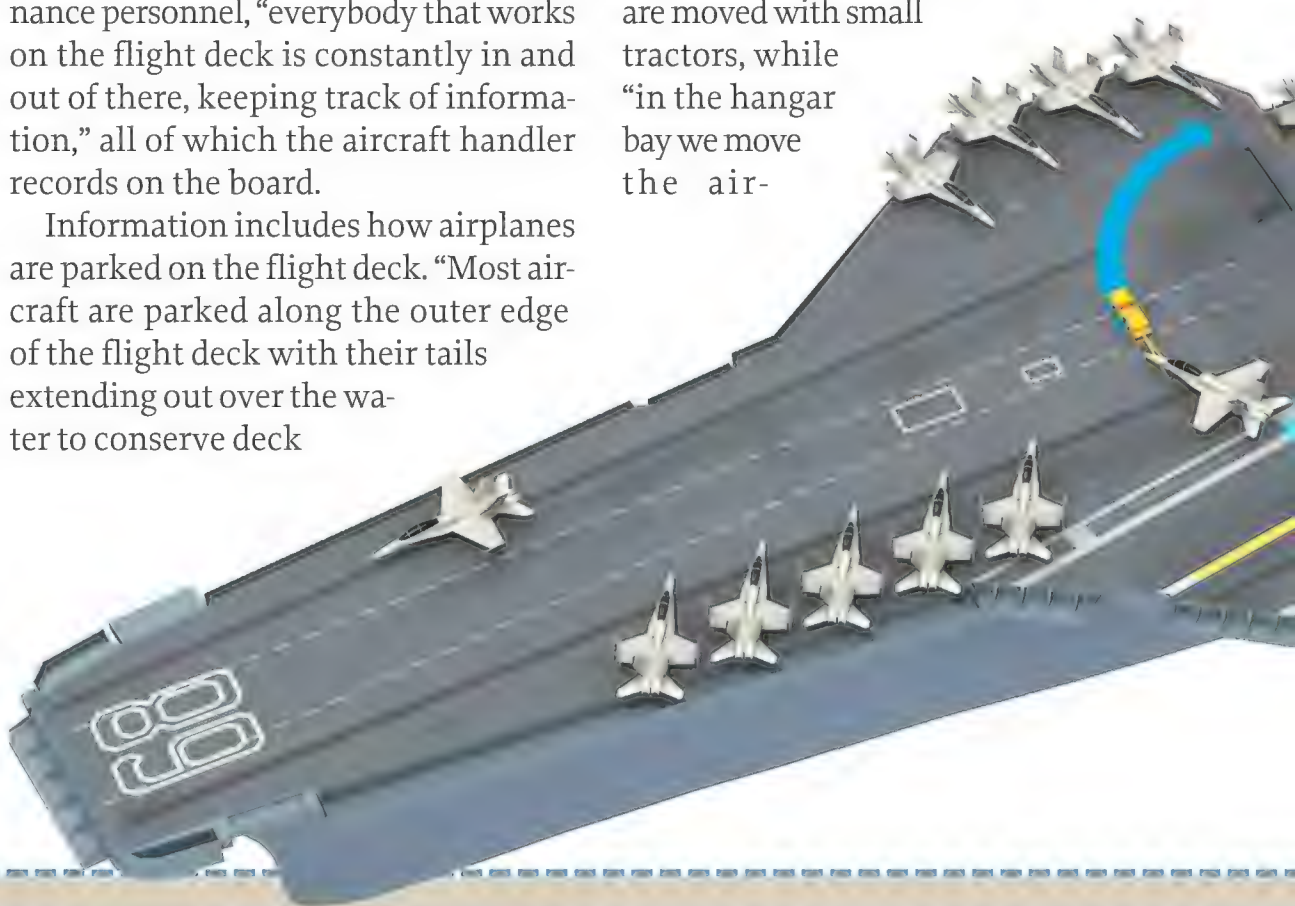
nuts and bolts, wing nuts, and washers," Spradlin says. There's no standard system of marking the airplane templates. "Every carrier has their own plan. What means something on one carrier may mean something different on another carrier. For the most part, we all keep track of the same information; we just may use a green pin for a first-go aircraft on one carrier, and the green pin on another carrier may mean something else."

The ouija board is the centerpiece of Flight Deck Control, located on the flight deck level of the "island," the structure that towers above the starboard carrier deck amidships. "It's one of the busiest spaces on the ship during flight operations," says Spradlin. Air crew, maintenance personnel, "everybody that works on the flight deck is constantly in and out of there, keeping track of information," all of which the aircraft handler records on the board.

Information includes how airplanes are parked on the flight deck. "Most aircraft are parked along the outer edge of the flight deck with their tails extending out over the water to conserve deck

space," says Spradlin. "Sometimes crews have to do maintenance on the rudder or the elevator or something that would normally be out over the water. Putting an orange tack on an aircraft template on the ouija board tells us that an aircraft needs to be parked with its tail over the flight deck."

Using the ouija board, the airplane handler oversees everyone involved in moving aircraft, including the "blue shirts," who chock airplane tires and chain them down, the "yellow shirts," who direct airplanes taxiing on deck, and the elevator operators, who move aircraft back and forth between the flight deck and the hangar deck. "We have four elevators, and we're capable of taking two aircraft at a time on each elevator," Spradlin says. "The hangar bay on this ship is divided into two bays. On the new *Nimitz*-class carriers they have three hangar bays. We can store about 27 to 29 aircraft in our hangar bay." The rest, of course, are either out on the flight deck or on a mission. On the flight deck, airplanes are moved with small tractors, while "in the hangar bay we move the air-



Board

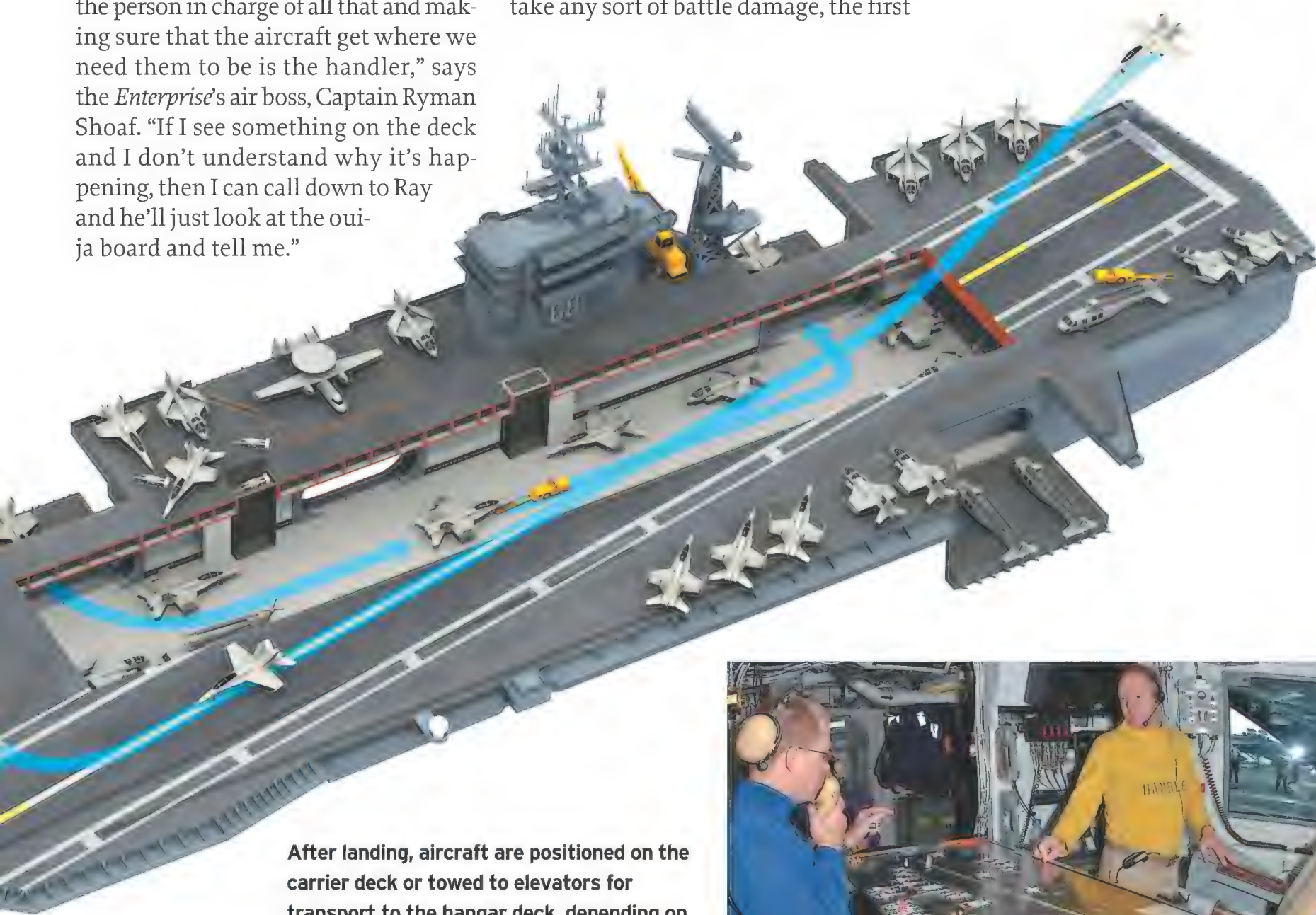
craft around with what we call spotting dollies, three-wheeled tractor-type contraptions with hydraulic arms.” And back in Flight Deck Control, every move is recorded on the ouija board.

The aircraft handler keeps the “air boss” updated with the data he needs to run flight operations from Primary Flight Control (Pri-Fly), several decks above, atop the island. “We have people in the hangar bay and flight deck physically controlling the aircraft, but the person in charge of all that and making sure that the aircraft get where we need them to be is the handler,” says the *Enterprise*’s air boss, Captain Ryman Shoaf. “If I see something on the deck and I don’t understand why it’s happening, then I can call down to Ray and he’ll just look at the ouija board and tell me.”

The ouija board system has been around since World War II, when the aircraft carrier came into its own as a warship, and hasn’t changed much since then. While practically everything else aboard the Navy’s warships is operated with state-of-the-art computers and digital technology, there’s a compelling reason that the ouija board remains so low-tech.

“Computers are nice, having electronic equipment is nice, but if you ever take any sort of battle damage, the first

thing that’s going to go out is all those powered systems,” says Shoaf. With the ouija board, “if ship’s power goes down, you don’t lose a thing. It’s still right there in front of you. It’s cheap, it’s reliable, and it’s been working for the last 60 years. It’s an effective system, there’s no real reason to update it and make it computerized, so nobody has.” Anyone who has lost a document on a computer can appreciate that thinking.



After landing, aircraft are positioned on the carrier deck or towed to elevators for transport to the hangar deck, depending on maintenance needs. Airman Timothy Johnson (at left) and Lieutenant Alan Proctor update the “ouija board” after a launch from the USS *Dwight D. Eisenhower*.



MCSN DAVID DANALS, USN

TOY STO

How tossing paper airplanes guided the career of an aerospace engineer.

BY GILES LAMBERTSON



ORY



WHILE ONLY IN ELEMENTARY SCHOOL, Ken Blackburn settled on airplane design as a life study and began to shape his future in paper. He crafted reams of paper airplanes to learn the rudiments of aerodynamics. Experimenting for years with variations on a fundamental airplane made from a square sheet of paper, he learned about concepts that most people don't encounter until they train to be pilots or study aerodynamics: dihedral angles, sink rates, and lift-to-drag ratios.

Through generations of folded aircraft, the youngster's ideas evolved. He added pinpricks to wings, for example, to produce turbulent airflow so air wouldn't "stick" to wing surfaces; later the tiny holes were dropped in favor of horizontal wing creases, which eventually gave way to diagonal creases.

In 1983, a year before earning a bachelor's degree in aerospace engineering from North Carolina State University, Blackburn earned a spot in the *Guinness Book of World Records* for longest paper airplane glide time. He subsequently raised that Guinness standard three times, and his last record-setting flight—27.6 seconds—has stood for a decade. In 1994 he published several of his designs in *The World Record Paper Airplane Book* (Workman Publishing Company). The "Valkyrie" on page 59 is a design from the book.

By some measurements, Blackburn has progressed little. Today a 45-year-old designer of military unmanned aerial vehicle prototypes, he works on pilotless craft so tiny their weight is measured in ounces and so slow they test the lower limits of aerodynamics. He and other engineers at the Air Force Research Laboratory, located at Eglin Air Force Base in Florida, labor in a branch of aeronautical engineering that in recent years has grown exponentially: Thousands of hand-launched UAVs, small enough to be carried in backpacks, have been deployed on surveillance missions in Iraq and Afghanistan.

Only a few inches in wingspan and about 15 ounces separate Blackburn's recent professional project—BATCAM, an acronym alluding to the craft's mission as an airborne battlefield camera—from the

gliders he creates out of 8- by 11-inch sheets of paper. And, in fact, the bedeviling exigencies of low-speed flight are common to both types of craft and are studied and resolved in strikingly similar ways.

Blackburn, for example, designed paper airplanes systematically: A model was folded and flown, its flight assessed and its design tweaked accordingly. Then the redesigned airplane was flown, followed by more tweaking and more flying. Blackburn called it trial and error.

BATCAM, developed for the Research Laboratory's Munitions Directorate, was engineered in much the same way, but professionals call it "the spiral method." This development process also relies on iteration, albeit a more sophisticated variety, with an initial prototype being computer-designed, built, and tested, then an improved prototype built and tested, then a third, and so on.

When Blackburn joined Jacobs Engineering at Eglin, the original BATCAM prototype had been delivered. He helped develop the first improved model. Air Force Special Forces stationed at Hurlburt Field, Florida, tested eight of the aircraft in 2006.

"The Air Force and I are in agreement that you learn a lot by going out and testing," Blackburn says. "I can generate a new tail shape, design it on the computer, and within a week have a prototype constructed and ready to fly. When you are working on a small airplane, and have all the tools, prototypes can come very quickly." (Blackburn's experience with flight is not limited to tiny aircraft. He has flown ultralights and at least once a week flies his Piper Warrior.)

Paper airplanes taught Blackburn that air is a real drag on light, slow-moving airframes. In order to be useful in the field, a small UAV must have an engine powerful enough to produce maneuvering thrust in buffeting winds. "Wind is a problem," says Blackburn, and an especially daunting one for micro-vehicles. "For a bug, I guess going with the wind is okay," he says, "but if you want to see what's on the other side of the hill, an unmanned vehicle sometimes has to fly against the wind."

Ken Blackburn (opposite) designs small, unmanned research craft for the military and small, unmanned paper airplanes for everybody. Above: One of Blackburn's creations.



Based on a research craft developed by Blackburn's team, the NightHawk surveillance UAV has flexible wings that can wrap around its fuselage. At the Air Force Research Laboratory (below), Blackburn studies components and flying qualities of miniature vehicles.

Weighing less than a pound, BATCAM features wings with a 21-inch span that are flexible enough to wrap around its carbon graphite fuselage so the craft can be stashed in a backpack tube. (The wings spring back into shape when the UAV is removed from the tube.) The airplane's battery-powered motor spins a propeller that pulls the GPS-guided craft a thousand feet into the air. From that vantage point, two TV cameras send images to a ground controller's computer screen.

For all its sophistication, BATCAM looks a lot like a toy. In fact, the softly serrated trailing edge of its wing puts one in mind of Batman. But Blackburn politely rejects the notion that the miniature aircraft is a plaything.

"I think a fair number of people do have the opinion that it is more of a recreational device than a tool," says Blackburn. "Where I became convinced otherwise is talking to soldiers and hearing them describe how it saved lives."

UNMANNED AIR VEHICLES

were not a priority in the Department of Defense in the 1980s, when Blackburn began work in St. Louis with McDonnell Douglas, later acquired by Boeing. His first engineering job was on full-size aircraft like the AV-8 Harrier jump jet. Only toward the end of his 19 years in St. Louis did Blackburn lead research in UAV development.

For the paper airplane enthusiast, it was a return to building aircraft small enough to hold in his hands. Boeing's UAV was a military "loiter craft" named Dominator, a 60-pound aircraft with a 12-foot wingspan capable of carrying several weapons. At one point, the en-

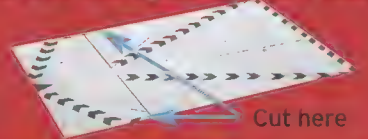


LEFT: GILES LAMBERTSON; TOP: NOAM ESHEL/DEFENSE UPDATE; OPPOSITE: ORLANDO ADIAO

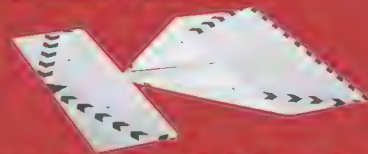
Make it fly →

Important: Cut on solid black lines; fold in on dashed lines; fold away on dotted lines.

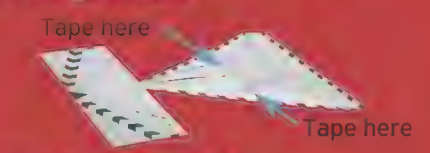
- 1 Crease along centerline (fold 9) and reopen. Cut along solid black lines.



- 2 Fold along lines 1 and 2 (aligning the halves of lines 3 and 4).



- 3 Fold along lines 3 and 4. Tape inner edges to large delta.



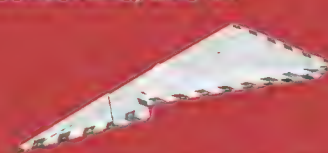
- 4 Fold along lines 5 and 6.



- 5 Fold along lines 7 and 8 (aligning the parts of lines 10 and 11). Tape inner edges.



- 6 Flip airplane over and fold in half along centerline, line 9.



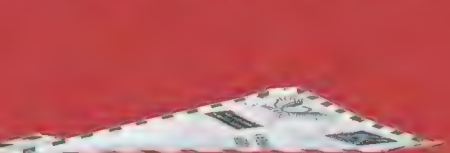
- 7 Fold one wing up along line 10.



- 8 Flip airplane over and fold other wing down along line 11.



- 9 Fold wingtips up along lines 12 and 13.



- 10 Bend upward at lines 10 and 11 so wings form a slight "Y" shape. Toss!



12



VIA AIR MAIL
POR VIA AEREA

9

13



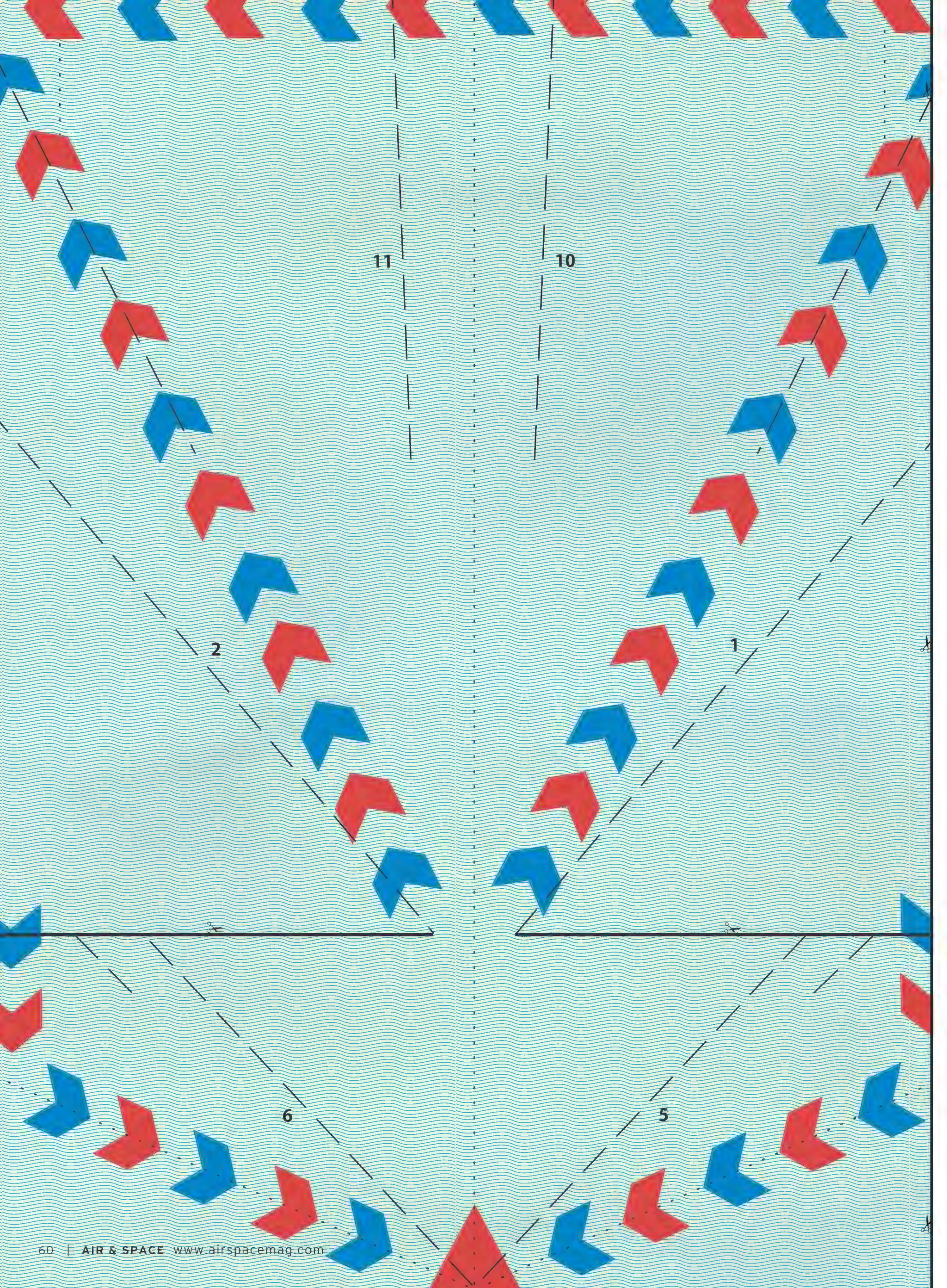
CORREO
AEREO

3

4

7

8



11

10

2

1

6

5

gineering team puzzled over how to refuel Dominator in flight.

"It's too small for a KC-135 tanker," Blackburn drolly explains. "So what I did was to help define a concept for refueling."

From his paper airplane tinkering, Blackburn learned to avoid preconceptions about fuselage and wing performance. "Sometimes the shapes surprise me," he says of his hand-folded airplanes. "I think, 'Well, this shape should do really well,' and sometimes it doesn't. Sometimes I come up with a shape that I think, 'Well, it looks good but it won't fly well,' and then it does fly well. You learn by doing. More than anything else, this has made me appreciate having an open mind."

Blackburn had experimented with asymmetrical designs in paper airplanes and knew that such configurations, while not particularly maneuverable, can be stable in flight. His colleagues warmed to his unorthodox idea and asked for a demonstration.

So Blackburn carried to a meeting an oddly configured paper airplane with a stabilizing canard on the right front of the fuselage and, on the left rear, a conventional wing with an upturned tip. With a quick toss, he floated it unwobbling across the conference room and into management acceptance as a concept vehicle for a UAV tanker.

While the Dominator has yet to be deployed, the prototype set the standard for endurance and performance in small air vehicles. Its asymmetrical-winged refueler—for which Blackburn was presented a Boeing Meritorious Invention Award—remains on the drawing board.

In the end, Blackburn's paper airplanes helped him land his current job at Jacobs Engineering. He came across an online job posting for an engineer with miniature-airplane credentials. "It combined my two passions in life—aeronautical engineering and small aircraft—and I saw an opportunity to boost my résumé with my paper airplane experience," Blackburn says.

Two weeks after an interview at Jacobs, he was working at Eglin. "For me, just as a hobby, I've tried to find every technical paper I can find to research small and very slow flying aircraft. That turned out to be the very knowledge I needed for my current job, and the people at Jacobs recognized it."

BY TOMORROW'S UAV STANDARDS, the Dominator with its 12-foot wings and even the one-pound BATCAM are archaically oversized. Half-pound micro-vehicles are already flying. The Defense Advanced Research Projects Agency is funding research on airfoils with radically better lift-to-drag characteristics




It's not all in the wrist. Blackburn got his whole body behind the toss in Atlanta's Georgia Dome that set a paper airplane world record in 1998.

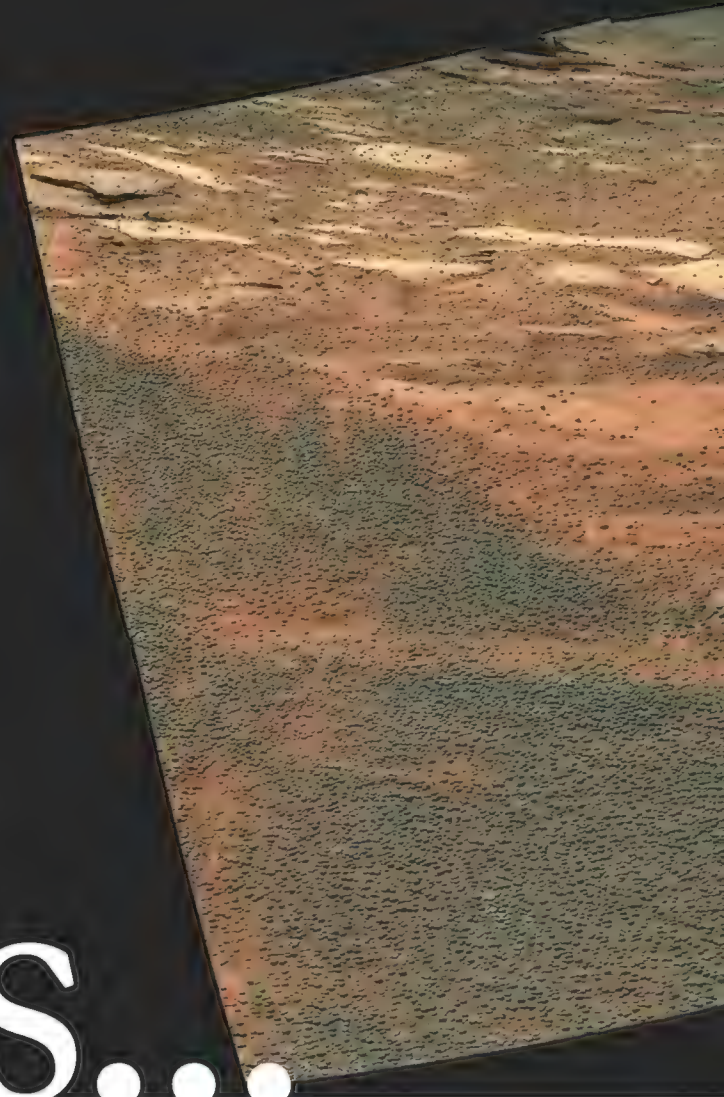
and powerfully efficient propulsion systems, all on an infinitesimal scale. Projects include insect-size flying robots fabricated at the University of California at Berkeley, and a nano-scale air vehicle at Oklahoma State University in Stillwater that weighs less than 10 grams and is only three inches long. Compared to such nanotechnology, paper airplanes are clunky contraptions.

"In the end, you do have to obey the laws of physics," Blackburn says, though he concedes that "there comes a time when engineering for these vehicles does start to lose basic aerodynamic principles, but that size is really, really small, when your wing is on the scale of molecules."

Blackburn's work and the more immediate goals of engineers at the Munitions Directorate are focused on airplanes bigger than a molecule but small enough to require basic research into their handling qualities and components. To be effective, a small air vehicle must be compact enough—and its wings large enough—to make slow-speed hand-launching possible for a soldier who probably has not studied biomechanics and shot-put techniques, as Blackburn did to maximize his Guinness airplane launches. The quest for the next-generation mini-UAV has formed another work-and-play connection at Jacobs Engineering: "Almost everyone in our group flies radio-controlled airplanes," says Blackburn. He calls the technologies in today's radio-controlled toys "remarkable" and adds, "Our job is to make sure we're not missing something" in RC components that could be used for military UAVs.

Blackburn's experience with toy airplanes, both plastic and paper, has taught him a final lesson: "It becomes progressively more difficult to make a useful airplane as it gets smaller." So attention, fourth-grade teachers: Don't just confiscate the paper glider that smacks into the blackboard while your back is turned. Encourage the designer. He or she may be the one to solve tomorrow's problems in low-speed, lightweight, unmanned flight. 

If I were to land on Mars...



RIVULETS STREAMED ACROSS MY WINDOW, breaking up into a chain of droplets like the streamers of rain on an airplane's window during a landing approach. Only these rivulets, red-orange hot, were driven by a Mach 25 breeze. Our Russian Soyuz capsule had pierced the veil-thin region of Earth's upper atmosphere at almost five miles per second, and was shedding sparks and bits of molten metal.

Many times I have marveled at the fiery trails of meteor showers that leave a glow in the night sky. Most of us have. We stop, wide-eyed, to observe the fleeting streaks. Sometimes we make a wish.

This time, we were the meteor. And yes, I for one was making a wish.

Our mission, in addition to having the glitches that seem to dog every space-flight, was unintentionally becoming a test run for a trip to and a landing on Mars: a weightless journey of many

months in space, followed by a high-speed entry into a planet's atmosphere, a sporty parachute deployment, a hard landing in the middle of a remote region, and no outside help for hours afterward. We would learn that our research on the International Space Station is already helping us prepare for the day humans land on Mars.

A few hours earlier I had been aboard the station with commander Kenneth Bowersox and flight engineer Nikolai

Budarin, my crewmates on Expedition 6. We had blasted off from the Kennedy Space Center in Florida aboard space shuttle *Endeavour* on November 23, 2002. This day, May 3, 2003, the three of us unknowingly prepared while orbiting Earth for a landing on Mars.

It had been a mission full of sudden turns. Three months before *Endeavour's* planned launch, NASA had removed one of the prime crew members for medical reasons. As his backup I found myself propelled into orbit long before my scheduled position in line. Then, on February 1, 2003, the *Columbia* disaster grounded the shuttle fleet, and our mission was extended from three and a half months to five and a half months. An astronaut colleague had told me before my flight that one should never venture into space without being mentally prepared to remain there for a year. His advice was half right.

We were returning in a Soyuz vehi-

A SMALL MALFUNCTION LANDS THREE ASTRONAUTS ON RUSSIA'S VERSION OF THE RED PLANET.



by Don Pettit

cle that had been docked to the station throughout our stay. We bid farewell to our Expedition 7 replacement crew before closing the hatch and strapping into our seats. The three of us were bound up like hapless flies in a seat belt web. We undocked, burned our de-orbit engine, and waited to enter the atmosphere. Then came the *rat-a-tat-tat* of pyrotechnic charges, like a ball-peen hammer pounding on the hull, which dissected the spacecraft into three pieces. With a slight lurch, we discarded two spent modules like empty soda bottles tossed out along the Route 66 of space.

Ken looked out his window and saw the propulsion module burning up as designed. I looked out my window and viewed the orbital module ablaze with incandescence. They resembled chunky filaments inside a light bulb. We marveled at the scene, unaware that these bits of disintegrating spacecraft shouldn't appear within our field of view. Unknown

to us, our reaction control system had failed, allowing the capsule to yaw out of the correct entry attitude.

Seconds later our warning panel lit up with a master caution that displayed the Cyrillic letters for "BC." It meant we were entering the atmosphere in a "ballistiki spusck," switching irreversibly from a piloted course to a ballistic, or unguided, one. This was the first entry flight of a Soyuz with an upgraded cockpit, and it was malfunctioning. We were coming in with no more grace than a cannon ball.

One of the nasty little side effects of a ballistic entry is that your G level climbs to more than twice that of a normal entry. So instead of experiencing 3 to 3.5 Gs, we were grunting under peak loadings above 8 Gs, after having lived for almost half a year in the zero G of space. In my spacesuit I weighed about 1,700 pounds. These gravitational swings can be rough on the body. But humans have

demonstrated throughout time that their physiology is robust and can operate under extremes. If as a species we were not so capable, all that would remain of *Homo sapiens* might be a thin fossil layer eroding from some Ethiopian hillside.

Following the high-G entry came the parachute opening sequence, with its carnival-ride oscillations. The chute is attached to the capsule by a single cable, and when it unfurls, the action causes the capsule to gyrate wildly. After a few short moments that seemed much longer than reality, the gyrations settled down. We were just starting to experience smooth sailing when our spacecraft made one last hurrah, a jolt as if we were in a boat that had just run aground. This was the re-hook system, which fires pyrotechnic charges to change the parachute attachment from a single point to a more stable four-point riser. From then on our ride was smooth.

Except when we hit the ground. The

OPPOSITE: NASA/JPL; ABOVE: MICHAEL SVOBODA/ISTOCK INTERNATIONAL INC.



NASA (2)

Soyuz is notorious for hard landings. To dampen the blow, a series of small rockets beneath the vehicle fired a few feet before impact. The Russians call them “soft landing rockets.” Long-stroke shock absorbers beneath our couches reduced the blow to something like a rear-end collision in rush hour traffic. After tumbling end over end a few times in another of those longer-than-reality moments, our capsule stopped on its side about 100 feet from the point of impact, having plowed enough dirt to create a small flower garden.

Because of the physics of a ballistic entry, you land almost 300 miles short of the target. After the chute had opened, we shared a brief radio dispatch with a search-and-rescue aircraft, so its crew knew that we were okay. But they lost contact before we could explain that our entry had been ballistic. Once below their radio horizon, we were out of range.

No one at Russian mission control knew where we were. The landing personnel waited for us at the planned site, and we had rudely failed to show up.

Where we did land, there were no ground support personnel to help us, and it would be hours before they came. We opened the hatch and crawled out. I felt like some gossamer sea creature that melts when removed from the ocean. The sudden presence of gravity turned me into an amoeba, and I oozed out of the capsule.

Perhaps the best way to describe what we felt like is to say what we did *not* feel.

We did not feel pain when we moved. And we did not lack strength. In orbit we had worked out for two hours a day, both cardiovascular and weightlifting exercises. We had the lean, muscled look of healthy people, not the atrophied bodies of those who had made the first long-duration spaceflights.

Our limbs felt heavy because our brains were not yet compensating for their weight. Like a lab scale that subtracts the weight of a beaker to measure only its contents, an Earth dweller’s brain accounts for the weight of the limbs. In orbit, we had lost this function, and it would take about 10 hours to regain it. Before exiting the Soyuz, each time I reached out to cycle a switch the trajectory of my hand would start off low, forcing me to hoist my arm to reach the correct spot on the instrument panel. Returning a tennis serve would have been more difficult.

Motion was unpleasant, a nuisance, provocative. Any head movement made my vestibular system complain bitterly. Of the three of us, I struggled with the worst symptoms, which is not uncommon for a rookie. Apparently, the body remembers the trials of past spaceflights, making each additional return easier.

When our post-landing chores were done, we chose to bask in the sun. It felt good to lie on my back and commune with Mother Earth. The sky was a most wonderful blue. The smell of freshly ground earth and crushed spring grass

Daily exercise kept the author (left) fit for his return to gravity. Crewmates Nikolai Budarin (in suit) and Ken Bowersox coped well in the Soyuz’s close quarters.

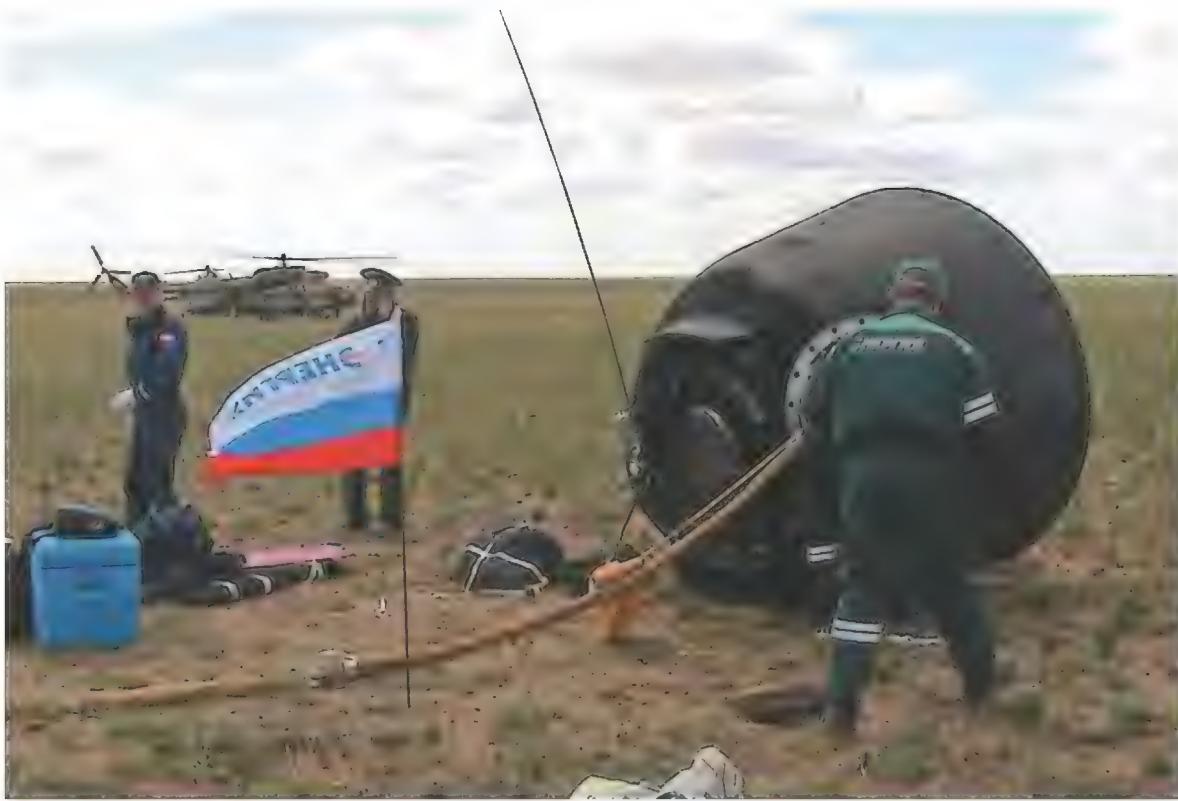
from our Soyuz’s tumble filled our noses. A sparrow’s song greeted our ears. A breeze touched our faces. The three of us propped our heads on our pile of survival equipment as if it were a giant communal pillow. Our bodies radiated outward like a three-spoke wheel.

By now we had been up for more than 18 hours, a long day by any measure, one that would end up lasting 36 hours by the time we went to sleep in a bed. But at that moment, sleep was impossible. My sensations, filled with newly rediscovered Earthly pleasures, overpowered any desire to sleep.

About two hours after the landing, we made radio contact with a search airplane. The crew had started a spiraling search pattern from the planned landing site and eventually flew within radio range. The helicopters arrived about three hours after that, proof of how isolated we were.

Four burly men came toward me with a stretcher, led by a Russian flight surgeon. I considered trying to negotiate in Russian that I could move without the stretcher, but opted for the easy approach and went for a ride in style, complete with real fur coverings. Obviously, I was lacking a measure of the right stuff.

So we had made a serendipitous discovery: Because of how the mission



Home on the range: The recovery crew (above) arrived five hours after Soyuz. Pettit (right, sitting) found gravity a drag, and a good reason to get on the stretcher.

unfolded and culminated in a lost recovery, it had an uncanny resemblance to a trip to, and a landing on, Mars. We showed that barriers associated with such a trip, in the form of human physical performance deficits, can be overcome with the knowledge gained from the similar effects experienced on long-duration space station missions.

The parallels are striking. First we lived in a weightless environment for five and a half months. Depending on the choice of propulsion, six months is a good estimate for a one-way trip to Mars. So our level of deconditioning was about the same as that of a crew arriving at the Red Planet. We piloted our own spacecraft through a high-G entry maneuver, similar to what a crew may have to do at Mars. Our landing sequence involved a combination of parachutes and landing rockets, culminating in a hard landing on dry ground in one of the more remote places on Earth. For reaching the Martian surface, such a combination is an attractive option. And the landing site will be remote.

On our own, we performed a number of basic operational tasks not unlike those a crew might execute after landing on Mars, such as spacecraft safing, which involves reading procedures, flipping switches, and pushing buttons on



DON PETTIT (3)

the control panel to power down unneeded equipment to extend battery life for the radios. Since the Soyuz capsule ended up on its side, we did this strapped into a seat fixed to a slanted ceiling. We then opened the hatch by ourselves, unstrapped, and crawled out. In my space-suit, I weighed 200 Earth pounds. On Mars, at 0.38 of Earth's gravity, it would require over 500 Earth pounds to equal the same loading on my body. So while future Mars astronauts will wear heavier suits with life support systems, they will be lighter there than I was in Earth's gravity. We deployed the survival gear that was scattered in numerous small bundles throughout the spacecraft. It takes a pair of strong hands to pull these bundles from their stowage in odd nooks and crannies—woolen clothes, food, water, a medical kit, a portable radio, and a flare-shooting pistol.

We performed all these operations with no outside help. We might as well have been on Mars.

One lesson I have learned from living on the space station is what it means to be home. The answer is directly proportional to how far you have traveled. Depending on the distance of your trip, it could mean when you've reached your driveway, your city, your state, or your country. A crew returning from Mars will undoubtedly consider themselves "home" when their trajectory places them in orbit around Earth. And for our serendipitous Mars landing on Earth, we were, at the same time, on another planet and at home. ✈



B-32 photo assistant Tony Marchione (left) was killed before he could realize his dream of becoming a pilot. Mourning Tokyo's destruction by B-29s, Japanese pilots in A6M5 Zeros (one pictured) and N1-K2J Shiden-Kais attacked Marchione's aircraft.

The Last to Die

BY STEPHEN HARDING

THE WAR IN THE PACIFIC
ENDED AS IT BEGAN,
WITH A SURPRISE
ATTACK BY JAPANESE
WARPLANES.

JUST AFTER 2 P.M. ON AUGUST 18, 1945, U.S. Army Sergeant Anthony J. Marchione bled to death in the clear, bright sky above Tokyo. A month shy of his 20th birthday, Marchione died like so many before him had in the Second World War—quietly, cradled in the arms of a buddy. What sets his death apart from that of other Allied airmen is that the young man from Pottstown, Pennsylvania, died after the Japanese had accepted the Allied terms of surrender. He was the last American killed in air combat in World War II.

I learned Marchione's story in the late 1990s while working on a book about the Consolidated B-32 bomber, the aircraft Marchione was flying in when he died. He had enlisted in the U.S. Army Air Forces less than two years earlier, in November 1943. The oldest of three children of Italian immigrants, he was a good-looking kid, five foot six and 125 pounds, with black hair and brown eyes. I learned from his sister, Theresa Sell, that he had enlisted because he had expected to get drafted. "He chose the Air Corps because he'd just always wanted to fly," she recalled in a 1997 interview. "I was still in high school when he went into the service, and with all the [patriotic fervor] at the time, my sister Geraldine and I thought it was neat that he was going."

Marchione wanted to be a pilot, but the Army had other plans; it trained him to be an aerial gunner. In November 1944, at Davis-Monthan Army Air Field in Arizona, he joined a Consolidated B-24 Liberator crew that was being transferred to Will Rogers Army Air Force Base in Oklahoma City for training in photo-reconnaissance. While pilots Robert Essig and John Ziegler learned the intricacies of flying the F-7,

the reconnaissance version of the B-24, Marchione and fellow gunners Rudolph Nudo, Frank Pallone, and Raymond Zech went through a course to become photographer's assistants. By August 1945, their unit, the 20th Reconnaissance Squadron, had moved to Okinawa, which had been captured by U.S. forces less than two months earlier. It was there, at Yontan Airfield, that Marchione first saw a Consolidated B-32 Dominator (see "The Last to Fly," p. 69).

The B-32s at Yontan were part of the 386th Bombardment Squadron, which conducted anti-shipping sweeps of the South China Sea and, if needed, could fly combat missions against the Japanese mainland. But Japan's surrender in mid-August abruptly changed the squadron's duties; crews now were to fly daytime photo-reconnaissance missions to monitor Tokyo's compliance with the cease-fire.

But there was another, more furtive reason for the flights, according to Rudolph Pugliese, who as a young lieutenant was the 386th's assistant intelligence officer. Besides gathering information on such things as the route that Allied occupation forces could follow into Tokyo, "the photo-recon missions were also intended to test the fidelity of the Japanese," Pugliese told me in 1997. "According to the terms of the cease-fire, our planes were supposed to be able to fly freely over Tokyo. If they actually could, that would mean the Japanese weren't planning any nasty surprises for the occupation forces." U.S. commanders wanted to be assured that the Japanese would not employ their still-robust air defense system, with early-warning radar stations, air raid sirens, and a fleet of fast fighter aircraft with experienced pilots ready to scramble to protect their homeland.



USAF



COURTESY RICH LACHARITE

The B-32 (top) was armed with 10 .50-caliber machine guns. Above: Marchione's crewmate, Joe Lacharite, was hit in the legs.



Above: Five months of raids by B-29s in 1945 destroyed Tokyo factories. The post-war disarmament terms allowed U.S. troops to torch Japan's airplanes (left).



ROBERT MIKESH (2)

WHILE THE B-32'S DESIGN included a belly camera just aft of its retractable ball turret, the 386th's Dominator crews did not include aerial photographers. For photo-recon sorties, mission planners enlisted crews from a pool of 20th Reconnaissance Squadron photographers, gunners trained as photo assistants, and

to the pool were Marchione and his F-7 navigator, Second Lieutenant Kurt Rupke. The pool system was not popular, Frank Pallone told me. "We called them 'bastard crews,' because guys were taken out of their regular crews and had to fly with people they might not ever have met before," he said. "Marchione, Nudo, and I

had been tent mates since the Philippines, and I think it bothered all of us that Tony was in the pool."

The first Dominator mission to include 20th personnel flew on August 16. A B-32 named *Hobo Queen II* and a second aircraft were dispatched to the Tokyo area; the second Dominator had to turn back when it developed engine trouble. *Hobo Queen II* pushed on and, though it was "painted" by Japanese early-warning radars while approaching and leaving the Tokyo area, its crew photographed the airfields at Katori and Konoiko, east of Tokyo, without interference.

Things didn't go as well the next day, however, when Lieutenant Colonel Selmon Wells, flying *Hobo Queen II*, led three other B-32s to the Japanese capital. Although just 25 at the time, Wells was a seasoned commander who had flown more than a dozen combat missions aboard a Douglas A-20 Havoc. He told me in 1998 that, despite the absence of Japanese activity the day before, he was "uneasy" about the August 17 mission. "I'd been at war for nearly two years by then, and I knew the Japanese were tenacious fighters who had no problem pulling dirty tricks on their enemies," Wells said. "I think I was subconsciously expecting something to happen."

Though Wells could not have known it at the time, events in Tokyo were virtually ensuring that something would.

BY AUGUST 13, it was obvious to diehards within Japan's government and military that Emperor Hirohito—shaken by the destruction of Hiroshima and Nagasaki just days earlier—intended to accept the Allies' demand for unconditional surrender. Though an attempted coup against the emperor had been foiled by loyal troops on the night of August 14, hardliners in the military swore to fight on. On August 15, Hirohito addressed his country by radio, announcing his intention to "bear the unbearable" and surrender to the Allies, intensifying the anger and sense of dishonor many in Japan's military felt.

Among those most capable of translating those feelings into action were the Japanese navy fighter pilots at Atsugi and Yokosuka airfields, outside Tokyo. At Atsugi, the 302nd Air Group was openly rebelling against Hirohito's cease-fire order. And the Yokosuka Air Group included

many pilots—such as aces Saburo Sakai and Sadamu Komachi—who felt Japan’s airspace should remain inviolate until a formal surrender document had actually been signed.

Both Atsugi and Yokosuka were home to some of Japan’s best fighter aircraft, including the Mitsubishi A6M5 Zero-Sen (known to the Allies as “Zeke”), the J2M3 Raiden (“Jack”), and the N1K2-J Shiden-Kai (“George”). The presence in the Tokyo area of such fighters, and of pilots skilled in attacking U.S. heavy bombers, practically guaranteed that Wells’ formation would receive a hostile response.

As the four B-32s made their way northeast along the coast of Kyushu on the August 17 mission, they were tracked by Japanese radar. Over Tokyo Bay, a few bursts of flak trailed the Dominators as they broke formation to begin their individual photo runs over different targets.

On the ground, pilots at Atsugi and Yokosuka had been warned of the approach of what were described as four B-24s. Aircraft lifted off from both airfields and raced to gain altitude, their pilots seeking to position themselves above the incoming bombers. While no one is certain as to which Japanese pilots took part in the attacks that day (in Saburo Sakai’s 1995 autobiography, for example, he says he participated, though other sources say he flew only on the 18th), there’s no doubt about what happened next.

Beginning at 10:30 a.m. and lasting for two hours, three of the B-32s were attacked by what their crews later described as Japanese army Ki.44 “Tojo” and Ki.61 “Tony” fighters (which looked somewhat like the Japanese navy’s “George” and “Jack,” respectively). The interceptors made multiple attacks, but the Dominators’ gunners largely kept them at bay with .50-caliber machine guns (each aircraft had 10). Though the B-32s suffered minor damage, no Americans were injured. Nor, apparently, were any of the Japanese: Though the B-32 gunners later claimed to have damaged one fighter and “probably destroyed” two others, surviving Japanese records list no losses for that day or the next.

As the Dominators began the long flight back to Okinawa, Wells radioed ahead a detailed report about the attacks. At Yontan, the news prompted “much confusion and surprise,” Pugliese recalled. “We were

all stunned by the attack, because we knew there were high-level talks going on between us and the Japanese. This wasn’t supposed to have happened, and we were all wondering if the war was actually over.”

According to statements by various commanders in mission reports, crew debriefings, and official histories, the attacks convinced U.S. commanders that it was vital to continue the recon missions over Tokyo. Allied planners needed to know whether the incident was an isolated act by diehards or an indication of Japan’s intent to reject the cease-fire and continue fighting.

Mission 230 A-8, carried out on August 18, was therefore something of a repeat of the previous day’s flight: It would cover many of the same targets, though it would involve only two B-32s; the other two were pulled from the flight because of mechanical problems. First Lieutenant

James Klein would lead the mission in *Hobo Queen II*, with First Lieutenant John R. Anderson in command of the second Dominator. In addition to its usual crew, each B-32 was provided a photo officer (a commissioned officer; usually a first lieutenant or captain), an aerial photographer (an enlisted man; usually a sergeant or staff sergeant), and a photo assistant from the 20th Recon Squadron. Tapped to fly with Anderson were Marchione, Rupke, and 29-year-old aerial photographer Staff Sergeant Joseph Lacharite. None had ever been aboard a Dominator.

Following an early-morning briefing during which they were warned of the possibility of Japanese fighter attacks, the crews climbed aboard the two B-32s and were in the air just before 7 a.m. Though Japanese radar tracked them on the approach to Tokyo, the airplanes encountered no op-

The Last to Fly

THE CONSOLIDATED B-32 DOMINATOR had one of the briefest combat careers of any U.S. military aircraft in World War II. It almost missed serving at all.

Developed in response to the same U.S. Army Air Forces requirement that resulted in the Boeing B-29 Superfortress, the four-engine B-32 was intended to be a larger, more capable follow-on to Consolidated’s successful B-24 Liberator bomber. First flown in September 1942, the B-32 underwent extensive flight tests that showed it to be a stable bombing platform, capable of cruising at nearly 300 mph at 30,000 feet and having a combat range of some 3,000 miles. But the aircraft was plagued by design and construction flaws (which the U.S. Army Air Forces blamed primarily on shoddy workmanship) that led to frequent main-gear collapses, catastrophic engine fires, and a host of other problems. So trouble-plagued was the Dominator’s development that only 115 were delivered.

That the B-32 saw any service overseas was due almost solely to the efforts of Lieutenant General George C. Kenney, commander of the Far East Air Force, based in Brisbane, Australia. Believing that heavy bombers flying from airfields within his command could help pummel Japan into submission, Kenney in July 1945 ordered several of his bomb squadrons to replace their nimble Douglas A-20 Havocs with the larger and more complex B-32s. The move was undertaken with surprising speed. In a 1998 interview, 386th Bombardment Squadron commander Captain Ferdinand L. Svore told me, “My conversion consisted of reading the B-32 manual and shooting two landings in the left seat. Upon successful completion of that second landing, I was designated a qualified B-32 squadron commander and instructor pilot.”

A month after Japan’s surrender in August 1945, all B-32 training on Okinawa was stopped. By the fall, all B-32s were flown to a scrap yard in Kingman, Arizona.



A 20-foot-tall tail helped make the B-32 a stable bombing platform.

position while on their photo runs. Then, Klein told me, “things went bad fast.”

Soon after the B-32s appeared over Tokyo, the air raid alarms sounded at the Yokosuka base. Sadamu Komachi recalled in a 1978 article in a Japanese magazine that the sight of American bombers flying so serenely above devastated Tokyo was too much for the gathered fighter pilots to bear. They ran to their aircraft and took off to intercept. *Hobo Queen II* was flying at about 20,000 feet and had just completed its last photo run when Klein got the first inkling of trouble.

“One of our gunners said he could see fighters taking off from one of the fields below us,” Klein said in 1998 (he died in 2004). “I turned the plane so I could see them, and sure enough, they were on their way up. I wasn’t too concerned about us, since it would take them a while to reach us, but Anderson was a good 10,000 feet below us.”

Klein radioed a warning to Anderson but got no response. As it turned out, though, Anderson’s tail gunner, Sergeant

John Houston, also saw the fighters. “By the time I spotted them, they were already at about the same altitude as we were,” Houston said. “I was facing backwards, and they were coming in from my 11 o’clock, three or four moving from my left to right. I just put the sight on them and started shooting.

One fighter came so close I couldn’t miss. I gave him about 50 rounds and saw hits on the wings and fuselage. He kept coming until he was within about 100 feet, and then he just blew up.”

In the two top turrets, Sergeant Benjamin Clayworth (who was forward) and Sergeant Jimmie Smart (aft) also engaged the attackers. Smart hammered a fighter coming in from 3 o’clock high, and as it rolled beneath the Dominator, Clayworth yelled over the intercom that he saw it explode. In the nose turret, Sergeant Burton Keller fired at those attackers making head-on runs after their passes at Klein’s aircraft.

Left: Sergeants Burton Keller and Benjamin Clayworth stand beneath the hole in the B-32’s fuselage made by the cannon round that killed Marchione. Below: *Hobo Queen II* in the Philippines.



COURTESY HENRY SAKAIDA (2)

Pair of aces: Between them, Japanese pilots Saburo Sakai (left) and Sadamu Komachi downed more than 100 Allied aircraft.

The only guns aboard Anderson’s B-32 not pumping out .50-caliber rounds were those in the belly turret, which had been inoperable even before the aircraft left Okinawa.

The turret problem didn’t seem to matter, since most of the Japanese were attacking Anderson’s Dominator from the front and sides. Komachi took another tack, however. He’d gotten above and ahead of the B-32, flipped inverted, and screamed down from 12 o’clock high. His fire raked the bomber, knocking out the left inboard engine. It was almost certainly during this attack that the first airman was injured aboard Anderson’s plane: A 20-mm cannon round hit the rear upper turret, sending shards of plexiglass into Smart’s forehead and left temple. He yelled “I’m hit!” and clambered down from the shattered turret.

Marchione and Lacharite were secur-



COURTESY BURTON J. KELLER



COURTESY STEPHEN HARDING

ing the camera gear when they heard Houston's call about incoming fighters. Just before Smart descended, Lacharite stepped to the Dominator's starboard waist observation window to try to spot the attackers.

"Just as I did that, I saw a plane headed right at me," Lacharite told me a few years before his death in 2000. "That's when I got hit. Rounds came right through the skin of the plane and hit me in both legs. I got spun around and landed on the floor. I grabbed the cord from one of the barracks bags that carried camera gear and wrapped it around one leg as a tourniquet. Then I wrapped an intercom cord around the other leg as Tony pulled me to a cot raised a few inches off the floor."

As he was moving Lacharite, Marchione was on the intercom telling Anderson what had happened, and the pilot replied that he was sending Rupke. Marchione had just turned back toward Lacharite when a 20-mm round punched through the right side of the aircraft and slammed into him, knocking him against the other side of the cabin. He had just slumped to the floor when Rupke arrived.

"When I got there, Tony was bleeding from a big hole in his chest," Rupke told me in 1997 (other eyewitnesses said Marchione was hit in the groin). "He was still conscious when I got to him, and I told him everything was going to be all right. He said 'Stay with me,' and I said 'Yes, I'll stay with you.' I did the best I could to stop the bleeding and I held him in my arms." As Rupke was trying to care for Marchione, Houston came forward from the tail turret, and he and Smart did what they could for Lacharite. Within minutes, the navigator, Second Lieutenant Thomas Robinson, and radar officer, Second Lieutenant Donald H. Smith, arrived to help. They gave Marchione oxygen and blood plasma and applied compression bandages to his wound, but about 30 minutes after being hit, the young gunner died in Rupke's arms.

As soon as the B-32s were attacked, both had gone into rapid dives and turned toward the sea. This allowed their airspeed to exceed that of the Japanese fighters, and both Dominator pilots began to pull away from their attackers.

The 10 attack passes it had undergone left Klein's airplane with no real damage, but Anderson's was in bad shape. Besides



JERRY VIRACOLA, VIA CHUCK VARNEY

the dead engine and shattered turret, the B-32 had lost partial rudder control and was punctured in about 30 places.

Both Dominators appeared over Yontan just after 6 p.m., and soon after landing they were surrounded by what the nose turret gunner Keller described as "every colonel in the Fifth Air Force, all wanting to know exactly what happened." (He told me this a few years before his death in 2004.) Marchione, Lacharite, and Smart were removed from the aircraft through the bomb bay and whisked away in ambulances, while the other crewmen were sequestered for a full debriefing.

IT WAS THE LAST AIR COMBAT of the war; the next day, as part of the cease-fire agreement, the propellers were removed from all Japanese fighters. From then on, Allied flights over Japan went unchallenged. Preparations for the occupation of Japan continued, and the Allied advance party landed at Atsugi on August 28, a week before the formal surrender.

While reporters on Okinawa filed stories about the August 18 attack almost as soon as it happened, the incident was largely buried under news of the coming occupation. The story got the biggest play in the hometown newspapers of those involved. The Fort Worth *Star Telegram* ran stories on Texans John Houston and Jimmie Smart, while Lacharite was written about in Massachusetts, where his recovery took several years. It was, of course, in the Marchione home in Pottstown that

Before flying on a B-32, Marchione (front, second from right) had been on a B-24 Liberator crew that included his buddies Rudy Nudo and Frank Pallone (front, second and third from left, respectively).

news of the attack hit hardest.

"When we heard the war was over, there was a tremendous celebration in town," Theresa Sell told me. "And of course, our family participated in that. Then, on the 19th, it all changed. I was at work, and I had just gone to the ladies' room when my boss sent someone in to get me. When I walked out, he wouldn't tell me what the trouble was, only that I had to go home. Of course, when I got there my mother and dad were in pretty bad shape."

The War Department had sent a telegram stating that Marchione had been killed in action, but it gave no details, nor did it mention the disposition of his remains. It was several weeks before Ralph Marchione, a shoemaker, and his wife Amelia got word that their son had been buried on Okinawa the day after his death. And it wasn't until three years later, on June 10, 1948, that they were notified of his impending repatriation. The casket bearing Marchione's remains returned to Pottstown—accompanied by his Army buddies and fellow Italian-Americans Frank Pallone and Rudy Nudo—on March 18, 1949. The last American to die in air combat in World War II was buried days later in St. Aloysius Old Cemetery with full military honors. —

Sightings

PICTURES WORTH A SECOND LOOK

"IT HAS NOTHING TO DO with alien spacecraft," says retired Air Force Historian Ray Puffer in an e-mail, "and no, there are no secret underground hangars at Edwards Air Force Base where we store alien ships and/or advanced aerospace vehicles with alien-based technology." The thing is just a huge compass, he says reassuringly, allegedly the world's largest, roughly three-quarters of a mile in diameter, etched by the Air Force half a century ago onto California's Rogers Dry Lake. Shown here in a montage of one-meter-resolution NASA satellite photos assembled in May 1998, the compass is situated between similarly marked runways and buildings at NASA's Dryden Flight Research Center.

The Air Force Flight Test Center apparently created the rose, oriented to magnetic north, so a test pilot could verify the heading on his cockpit compass with a glance out the window. "The oldtimers say that it was actually used for that purpose a few times," says Puffer. "This was a rough-and-ready (read: cheap and fast) project that the Flight Test Center did with its existing resources, not an elaborate project that had to be contracted out. I myself could make a perfect circle with just a sharp stake and a large ball of twine." The job was so low-key that any records with dates, if they ever existed, have vanished from Edwards and Dryden. Base historians say the rose doesn't appear in photos prior to March 1958, but that by June it was complete.

"The idea was simply to make it large enough to be spotted easily from the air," says Puffer. "All of the western Mojave is a flat, dun-colored surface, and the eye readily picks out an artificially round, black shape." Even returning space shuttle pilots, he adds, can spot it from afar. The Air Force's civil engineers repaint its lines and numbers with a special vehicle every two or three years to fight the effects of high winds, summer temperatures between 135 and 140 degrees Fahrenheit just above the surface, and the occasional few inches of water on the lakebed. As for its accuracy, that faded for good. "Gyro compasses and Mother Nature soon ended that usefulness," says Puffer. While Earth's magnetic pole has moved around northern Canada, the compass rose remains set in stone, and sometimes stuck in the mud.





Then & Now

FROZEN MOMENTS AS TIME MARCHES ON

Wash Day

FOR DECADES, the U.S. Air Force had no standard approach for washing its airplanes. Crews would simply scrub off the grime with hoses and whatever was at hand—mops, rags, sponges, or squirt bottles. But all the grease and fluids would run off with the washwater, making a big mess. Toxic chemicals like benzene, chromium, or mercury, along with the solvents used to remove them, sometimes soaked into the ground or drained into nearby waterways.

One of the earliest documented aircraft wash racks—a structure similar to a drive-through car wash—was built in 1953 at Carswell Air Force Base in Fort Worth, Texas. There the problem was wastewater washing into a storm drain system that emptied into the Trinity River. So Carswell borrowed a portable flotation unit to corral the wastewater until a permanent treatment plant was built.

Federal environmental laws of the 1970s put bases under tight restrictions to catch the runoff on wash day. At bases near saltwater, like Mississippi's Keesler and Florida's Homestead, aircraft taxi through a special ramp hose system with drains to collect and recycle the

water. The airplanes are rinsed after each flight, and get a full wash every 30 days.

At McChord Air Force Base in Washington state, aircraft are washed in one of three hangars, two of which are big enough to accommodate the giant C-17 Globemaster III transport. The hangar floors are sloped slightly, with three trenches to collect the water.

Pressure-washing a C-17 takes eight workers about 12 hours and 500 to 700 gallons of water. Each worker wears a face shield and apron to guard against harsh solvents and uses a three-foot-long washer wand.

"We do 30 major washes a month and maybe 100 minor washes," says McChord quality assurance manager John Bobincheck. The base also fills requests to clean C-130 Hercules transports, KC-135 Stratotankers, and Army CH-47 Chinook helicopters. Wheel wells get the grimeiest; bird strikes leave the most gunk.

A thorough cleaning involves doing the interior as well, and by hand. "The best way to describe a dirty transport



With mops and a hose, a crew scrubs a Martin B-26 Marauder bomber in 1944.

aircraft is if you've taken your kids across country by car," says Bobincheck. "There's candy wrappers and box lunches and foam earplugs and general dirt and debris. If we're loading vehicles, they have to go up a ramp and that will often knock whatever's on the vehicle loose into the underfloor [a metal gridwork to tie down cargo]. You pressure-wash and then vacuum up the excess water."

Some bases filter their washwater and discharge it into the local sewer system, while others recycle and reuse it. Both methods are covered by the guidelines in a 360-page Air Force technical order issued in 2003 that specifies every scour pad, solvent, and means of disposal involved in washing aircraft, categorized by Air Force base.

It also provides recommendations on how often to wash the airplanes. Those in areas susceptible to corrosive saltwater get a mandatory once-a-month scrub, but airplanes at the vast majority of bases—including those in Afghanistan and Iraq—can go quite a bit longer between washes, up to six months. But the bathing is not about vanity; the washes keep corrosion at bay and help ensure that every aircraft stays airworthy.

ROGER A. MOLA



A C-130J Hercules at Keesler Air Force Base gets rinsed by ramp hoses. It takes five minutes to taxi through the "bird bath," which uses 10,000 gallons of water per rinse.

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A Test Pilot Tells All

The triumphs and tragedies of those who risked their lives over the dry lakes of southern California.

Contrails Over the Mojave: The Golden Age of Jet Flight Testing at Edwards Air Force Base

by George J. Marrett. Naval Institute Press, 2008. 230 pp., \$29.95.

SINCE CONTRAILS OVER THE MOJAVE is the account of a purported golden age, part of my slight dismay with this book is that I'd expected it to be about a more glamorous time, never having thought the era of flawed F-111s, brutish F-4s, and pointless F-104s was the golden age of anything. Marrett, who either flew or chased them all, as well as a huge variety of other jets and turboprops, from helicopters to transports, was there at the time, though, and he inevitably sees a golden glow.

But Marrett's descriptions of what a pig the F-4 was, of the aileron reversal that occurred when the B-47's boost failed (yoke right, airplane banks left), and of an NF-104 altitude record attempt that almost killed U.S. Air Force test pilot Chuck Yeager, due to

his arrogance, are worth the price of admission. Marrett was there when the XB-70 Valkyrie, on an ill-advised PR photo flight, had a midair and crashed, and he tells us that wary test pilots called it Cecil the Seasick Sea Serpent. And you'll learn only from Marrett that at 63, the beloved air racing pilot Pancho Barnes "had a huge round head, the largest I had ever seen on a woman. Her face was wrinkled and red—she was not very attractive."

Unfortunately, Marrett is an unselective writer. Every time a fellow test pilot is first mentioned, we're told where he played high school football, which medals he's won, every aircraft type he's ever flown, and a variety of other slow-the-flow trivia.

Marrett lists everybody's name with the nickname—Robert "Bob," Michael "Mike," Charles "Chuck" (indeed just about every time Yeager is mentioned), Joseph "Joe," and on and on. Marrett doesn't simply pull out his



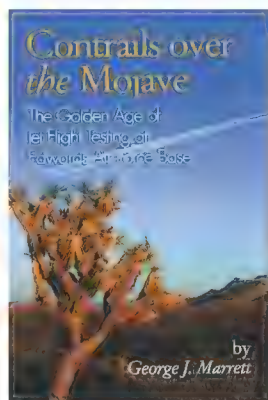
George J. Marrett learned to fly jets in a Lockheed T-33 (above), a skill that led to 25 years as a test pilot for the U.S. Air Force and Hughes Aircraft.

camera, he hefts his "Argus C3 camera." They're clinkers he can't resist adding.

Marrett's wife once joked that her husband "might be the only person to write a book who has never read one." Perhaps Marrett should have studied a bit more what makes the pace of prose

work, and when unvarnished information isn't enough.

STEPHAN WILKINSON, A FREQUENT BOOK REVIEWER FOR *AIR & SPACE*/SMITHSONIAN, IS THE AUTHOR OF *THE GOLD-PLATED PORSCHE: HOW I SANK A SMALL FORTUNE INTO A USED CAR, AND OTHER MISADVENTURES* (LYONS PRESS, 2005).



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Reviews & Previews

Final Countdown: NASA and the End of the Space Shuttle Program

by Pat Duggins. University Press of Florida, 2007. 239 pp., \$24.95.

IN FINAL COUNTDOWN, Pat Duggins takes on the history of the space shuttle and NASA's future direction. Duggins, a reporter for National Public Radio, has covered space issues for nearly two decades. Listeners, even astronauts, give him high marks for his shuttle mission reports, heard nationwide.

Final Countdown launches directly into the origins of NASA's new deep-space vehicles: the Ares launchers and the Orion crew module. Duggins explains how the Constellation program emerged from the shuttle's 30-year record of triumph and tragedy. "Don't call unless it blows up," one uninterested editor told Duggins just before

Challenger's final mission. That 1986 failure and the 2003 *Columbia* accident enable the author to examine both the shuttle's impressive technology and its design vulnerabilities.

Duggins' on-air success at translating complex space concepts into laymen's terms should have helped this narrative, but his writing is undercut by a long list of historical and technical errors: orbiter cockpit windows each have three glass panes, not two. Gordon Cooper flew Gemini 5, not Gemini 8. The shuttle's wings give it cross-range, not "downrange." Engine nozzles don't "belch thrust," they belch exhaust.

A more careful editor would have hired a space-savvy fact checker, and might have tightened up some of Duggins' less-pertinent reminiscences. Additionally, the book's black-and-white images can't do justice to the visual splendor of spaceflight. For readers looking for a definitive account of the shuttle era, *Final Countdown* isn't the last word.

TOM JONES IS A FORMER NASA ASTRONAUT.



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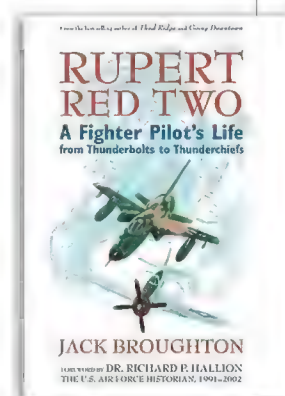
Rupert Red Two: A Fighter Pilot's Life From Thunderbolts to Thunderchiefs

by Jack Broughton. Zenith Press, 2008. 352 pp., \$26.95.

JACK BROUGHTON has written an intriguing memoir encompassing his entire U.S. Air Force career. His storytelling spans his appointment to West Point, flying school, years leading the Thunderbirds, court-martial during the Vietnam War (a couple of his pilots fired on Cam Pha Harbor when they shouldn't have), and a post-military career flying just about anything with a stick. Broughton knows how to tell a story; his talents show as he recalls escorting General Douglas MacArthur's transport on the latter's farewell tour of South Korea, and nearly ripping the wing off his Thunderbolt while buzzing Augsburg, Germany.

The book bogs down during the chapter about flying with the Thunderbirds, and it ends rather abruptly after Broughton's post-Air Force work on the B-1 bomber and the space shuttle *Endeavour*. Otherwise, it's a lively tale with sharp observations. Take this one: "...a primary-duty Thud pilot needed one hundred missions north to earn a ticket home. However, statistics proved that the average mission expectancy of a Thud driver was sixty-five.... [T]heir definition of a supreme optimist was a Thud driver who quit smoking because he was afraid of dying from lung cancer." Now this is a guy who would be fun to spend an afternoon hangar-flying with.

PHIL SCOTT IS THE AUTHOR OF *HEMINGWAY'S HURRICANE: THE GREAT FLORIDA KEYS STORM OF 1935* (INTERNATIONAL MARINE/RAGGED MOUNTAIN PRESS, 2005). HE WROTE ABOUT THE RESTORATION OF THE USS *INTREPID* FOR THE AUG./SEPT. 2008 ISSUE.



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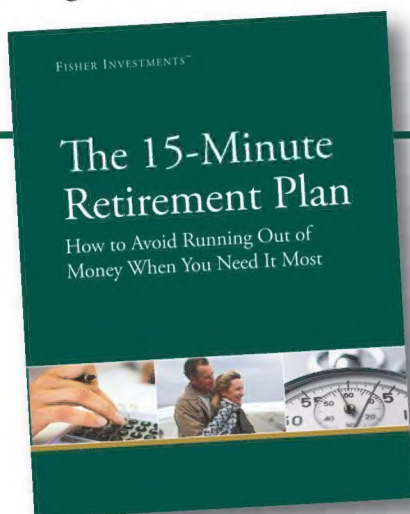
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IN THE NEXT ISSUE

KILLER WAVE

Wrestling with ground resonance, the demon that's demolished helicopters.

THE BLACK EAGLE OF HARLEM

The amazing adventures of Hubert Fauntleroy Julian: a colonel in the Ethiopian air force, a barnstormer, and an inveterate publicity hound.

RED AND THE ROBOTS

William "Red" Whittaker's robots have dropped into volcanoes, trudged through deserts, and crawled into nuclear power plants. Their next job is out of this world.

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YOU'VE GOT MAILPLANES!

This year's Antique Airplane Association fly-in, in Blakesburg, Iowa, celebrates the 90th anniversary of U.S. airmail service with a reproduction de Havilland D.H. 4 and the world's only flying Boeing 40C.



Addison Pemberton and his 1928 Boeing 40C — along with Larry Tobin in his 1927 Stearman C3B and Ben Scott in his 1930 Stearman 4E — celebrated the 90th anniversary of airmail service in the United States by tracing the historic transcontinental airmail route.

COMING TO www.airspacemag.com

An astronaut's view of cities at night; how NASA would perform a shuttle rescue in orbit; time-lapse video of Boeing's elite "Airplane On Ground" repair team at work (see p. 22).

Credits

The Village of Tempelhof. Charles Brady lives in Berlin and the Czech Republic. He visits the United States every year.

The Alraigo Incident. Tim Wright is the first journalist that Ian Watson has spoken to since the Harrier-Alraigo incident.

Airliner Repair, 24/7. Frequent contributor Stephen Joiner writes about aviation from his home in southern California.

Restoration: The Memphis Belle. Mark Bernstein writes about American history. His current project is a biography of former Ohio governor John Gilligan.

Accidental Classic. Mark Huber has written about old and odd airplanes for *Air & Space/Smithsonian* since 2000.

Fly Us to the Moon. Michael Cassutt, a novelist and television writer in Studio City, California, is the author of *Who's Who in Space* (3rd edition, Macmillan Gale, 1999).

How Things Work: The Ouija Board. Mark Wolverton's latest book, *A Life in Twilight: The Final Years of J. Robert Oppenheimer*, will be published in November by St. Martin's Press.

Toy Story. Giles Lambertson, a writer living in North Carolina, found several of the manuscript pages for this article to be airworthy.

If I Were to Land on Mars... Don Pettit is training for a fall launch aboard the space shuttle *Endeavour*, a mission that will resupply the International Space Station.

The Last to Die. Stephen Harding, a Washington, D.C.-based writer, is the author of seven books.

Wash Day. Roger A. Mola is a researcher at *Air & Space*.

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Moments & Milestones

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The First “A” in NASA

This October 1, NASA celebrates its 50th anniversary. To the public, “NASA” means Mercury, Gemini, Apollo, the shuttle—all things space. But of the agency’s half-century of research, some of its most dramatic advances have been in aeronautics.

NASA’s predecessor was the National

turning the vortex of air that forms at the wingtip into a force that actually adds a little thrust. It works like a boat’s sail tacking into the wind. Winglets have recently grown very popular. You’ll see them today on some airliners and business jets.

Both the supercritical wing and the

particularly relevant today, as it enables aircraft to calculate flight paths that are the most fuel-efficient.

NASA-developed improvements can be found in engines too. Advanced combustors reduce pollutants like nitrogen oxides. And should a fan blade fracture and fly off, passengers are protected by tough containment structures. Another reason for air travelers to thank NASA.

And now that all sorts of aircraft are made not of aluminum but rather of tough composites, like Kevlar and carbon-fiber, you’ll be glad to know NASA has researched the materials for decades, and helped solved some major composite-related problems. For example, composite airframes face different challenges in lightning strikes. Composites are non-conductive, so if a composite aircraft is hit by lightning, the electricity will pursue a path of least resistance, burning the composite as it goes. NASA helped develop a solution: embedding metal in the composite. The metal disperses the lightning’s charge through the exterior skin, and away from fuel and instruments.

NASA helped industry to develop the standards for what we now call the glass cockpit—electronic screens that have replaced electromechanical instruments and their thousands of delicate parts. Pilots now peer at a world that is more intuitive than the old one.

Aircraft already have technology to detect icing, and wind shear sensing is helping to eliminate rough rides. Soon the craft will incorporate software that changes the way the airplane is controlled if it suffers damage.

So on its 50th anniversary, let’s tip our wings to NASA. The folks there have earned a salute.

■ ■ ■ GEORGE C. LARSON, MEMBER, NAA



Advisory Committee for Aeronautics. Today, the NACA is best known for the series of airfoils its engineers developed. Current jets, and even some light general aviation aircraft, fly on wings with airfoils designed not at the NACA but at NASA. The C-17 Globemaster III transport, for example, has what is called a supercritical wing, an airfoil developed at NASA in the 1960s. A supercritical wing makes jets more efficient by delaying the formation of drag-producing shock waves on the wing’s upper surface when aircraft near transonic speeds. With the upper curve of the airfoil flattened, the acceleration of air over the upper surface is reduced, and shock waves are prevented.

Another wing innovation the agency developed, dating back to the 1970s, is the winglet, which reduces drag by

Fifty years ago, an aircraft hangar at Ohio’s Lewis Research Center (now Glenn) changed markings, from NACA to NASA. But aeronautical research continues at NASA centers to this day.

winglet were the products of not just one agency but one engineer: Richard Whitcomb, at NASA’s Langley center in Virginia (and earlier, at the NACA).

Also in the 1970s, NASA operated a Boeing 737 as a flying laboratory, using it to develop numerous technologies and concepts, primarily for the airline industry. In four-dimensional navigation, for example, computing systems guide the airplane in three-dimensional space as well as the fourth dimension: time. In other words, you end up where you should, precisely when you should. The concept is

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